POWER PLANT ENGINEERING

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Power for Making the Steinway Piano

ALTHOUGH AN OLD PLANT, MOST OF THE ORIGINAL EQUIPMENT HAS BEEN REPLACED BY MODERN APPARATUS

STEINWAY is a name that brings to mind but one thing—pianos. It needs no qualifications. It means in the piano world that Pierce-Arrow means in the automobile world or what the name Stetson stands for among hats. The Steinway is the acknowledged aristocrat of the piano world.

Four generations ago, when Henry Steinway made his first piano, he called it "a labor of love," because he made it in the odd hours of his time as a present to his bride. And during the four generations since that time, the making of the Steinway has continued to be, in a different sense, perhaps, a labor of love. It is remarkable in the annals of family inheritance that in each generation of the Steinway family there has been some inventive genius who has contributed improvements which have carried the construction of this piano to greater and greater heights.

While it would be interesting to know all the details regarding the making of the Steinway piano, it is not within the scope of this article to discuss them. We shall, however, endeavor to present a few of the facts concerning the power required in their manufacture and to describe one of the plants supplying this power.

Steinway and Sons operate two factories, both located at Steinway, Long Island City, New York. This article, however, is concerned only with factory No. 1, otherwise known as the Riker Avenue Factory.

FIG. 1. BOILER HOUSE SHOWING NEW STIRLING BOILERS

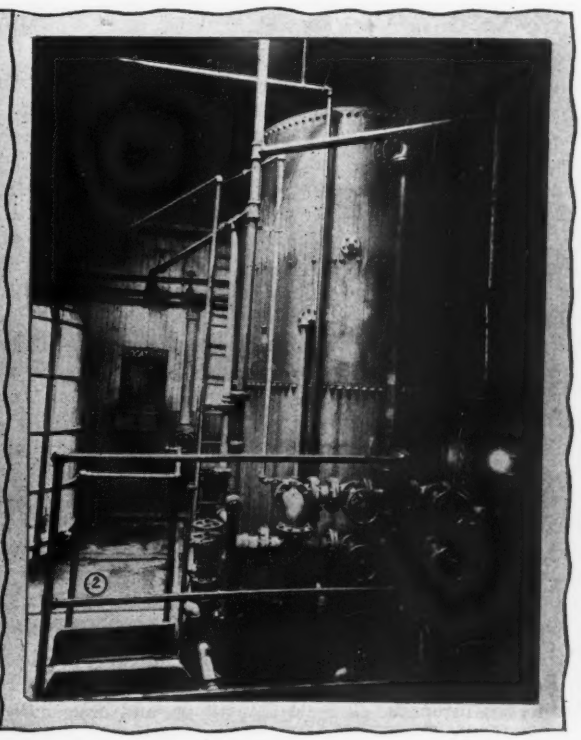


FIG. 2. THE ZEOLITE WATER SOFTENING EQUIPMENT

While the power plant serving this factory is a comparatively old plant, and is not as modern in external appearance as some of the more recent plants, it is

thoroughly efficient, when considered from an operating standpoint. Practically all of the originally installed equipment has been replaced by modern equipment, which fact, no doubt, together with an excellent system of management is responsible for the high degree of efficiency maintained.

In describing this plant, let us begin at the dock, where the coal comes in. This dock as may be noted is located upon the premises, upon Steinway creek which connects with Long Island Sound. The coal, which is delivered in 500-T. barges, is removed by means of an

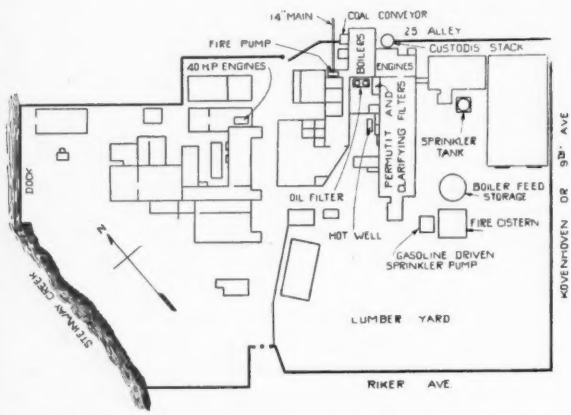


FIG. 3. PLAN OF DITMAR AVE. FACTORY OF STEINWAY AND SONS

electric crane which discharges into an overhead hopper, or upon the conveyor, according to whether coal is to be used under the boilers immediately or whether it is to go in storage. If it is desired to store the coal, a Barber Green electric portable conveyor is used to transfer it from the dock to a large storage bin nearby. If, on the other hand, the coal is to be used at once, it is delivered by gravity into trucks which transport it to the boiler house some distance away.

At the boiler house, trucks deliver the fuel directly into a hopper, as shown in Figs. 4 and 5, which feeds into the buckets of a C. E. Hunt bucket elevator. This elevator is electrically operated and discharges into a 50-T. overhead concrete coal bin in the boiler room. In the boiler room a weigh larry operating on overhead rails through the full length of the room, receives coal from the bin and distributes it to the various boilers.

As the plant is a comparatively small one as boiler plants go, hand firing is employed. This has been found satisfactory as well as economical.

Boiler House

The boiler installation consists of two new 250 hp. Babcock & Wilcox, Stirling boilers and four 125-hp. Bigelow horizontal return tubular units. The latter have been in operation from 9 to 18 yr. and have individual stacks.

The Stirling boilers are fitted with Dean dumping grates, each having approximately 75 sq. ft. of surface. They each have 256—3¼in. tubes and a heating surface of 2523 sq. ft. This gives a ratio of grate surface to heating surface of 1 to 33.6, which is sufficient to develop rated capacity with buckwheat anthracite. These boilers were first placed in operation in September, 1920.

Both of the new boilers connect into a horizontal steel breeching which in turn connects into the base of a 150-ft. Custodis stack. The latter is 8 ft. in diameter at the base and 7 ft. at the top. An automatic damper regulator in the breeching controls the draft above the fuel bed.

Under normal operating conditions, the new stack provides sufficient natural draft for economical operation. A complete forced draft system is installed, however, for use in emergency conditions such as a partial boiler shutdown or with coal of inferior quality in the winter time. This forced draft system is arranged to supply the old horizontal return tubular boilers as well as the new Stirling units.

Additional equipment consists of National Flue Cleaner Co's. soot blowers on the horizontal return tubular boilers and Diamond soot blowers on the Stirlings. An extra or auxiliary boiler feed line fitted with non-return stop valves and Williams Automatic feed water regulators connects into each boiler. The boiler settings are constructed with the Lemb system of interlocking fire brick, and the exterior covered with B.t.u. Asphaltum Cement.

Steam pressure of 110 lb. gage is normally carried. In summer months, that is, from May until September,

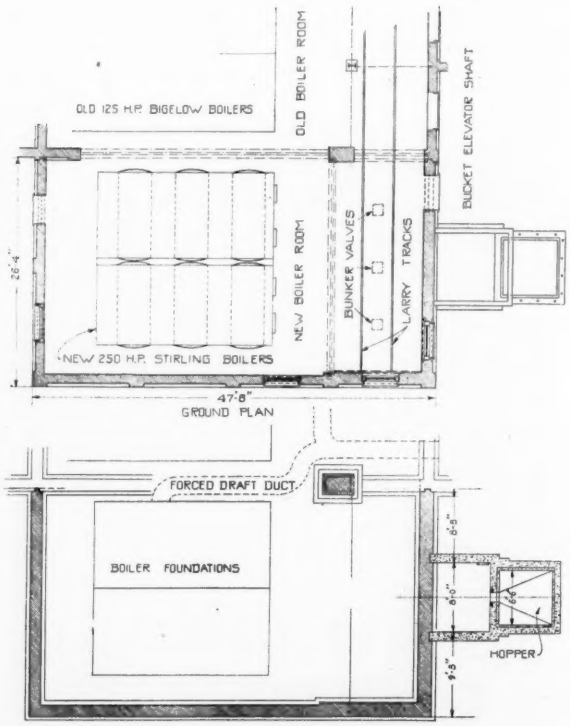


FIG. 4. PLAN OF NEW BOILER ROOM

an overall daily evaporation of 7.4 lb. of water per lb. of coal is obtained. During this period, the average coal consumption including shavings fired under the horizontal return tubular boilers is 290 T. per month.

During the winter months (October to April) the average overall daily evaporation is 7.1 lb. of coal and the average consumption including shavings is 385 T. per month.

The coal used is No. 1 buckwheat anthracite which has a rated capacity of 20,000 gal. of water per 24-

All coal is analyzed and although it is purchased either at a high or low B.t.u. value, the analysis furnishes a basis for price adjustment.

The boiler room is operated on an 8-hr. shift basis, the boiler room force consisting of three boiler room engineers, only one of which is on duty on each shift, and who have under their charge the entire boiler room and its operation. In addition, three firemen perform the firing and cleaning of the fires, and to this force is added one helper in the winter and one helper during the daytime the year round. Also included in the boiler room force is one man to handle the shavings, two oilers, one shop oiler who tends to transmission oiling, a filter man, and a pump attendant. This makes a total of 14 men in winter and 12 in summer, although it is perhaps not quite correct to include the shop oiler in the boiler and engine room force.

Approximately 20 to 25 per cent of the fuel used at this plant is wood waste, consisting mostly of shavings and sawdust. The entire woodworking plant is piped with a shaving exhaust system, discharging into a vault in the boiler room.

Feed Water

Feed water to the boilers is heated in an open heater which is heated by exhaust steam from the plant auxiliaries. A temperature of at least 212 deg. F. is maintained on the feed water system, a record of which is kept by means of a Bristol recording thermometer. A typical chart taken from this thermometer is shown in Fig. 10 (B). This as may be noted shows a temperature varying between 215 and 220 deg. which to say the least is good performance.

Two duplex feed pumps, controlled by Watts differential pump regulators, are provided.

The water supply and softening system at this plant is of particular interest. All water used is well water of a high degree of hardness, usually about 26 grains. Water of this hardness naturally caused considerable trouble in the operation of the boilers due to the rapid formation of scale. Before the present Permutit water softening system was installed, the average life of the boiler tubes was 2 yr. and it was necessary to turbine them every two weeks. Not only was the trouble confined to the boilers but to the connected water piping and gages as well.

In Fig. 8, A, B, and C are shown in sections of piping removed from the hot water lines at the Steinway plant, before the present water treating apparatus was installed. In A is shown an elbow. A section of the pipe was broken off to show the manner in which scale deposited in this elbow. The specimen shown at B is another view of this elbow and gives a good idea of what the engineers had to contend with at this plant. At C is shown a section of pipe that screws into this elbow and serves to indicate that the scale deposits form throughout all sections of piping and are not necessarily confined to bends or angles.

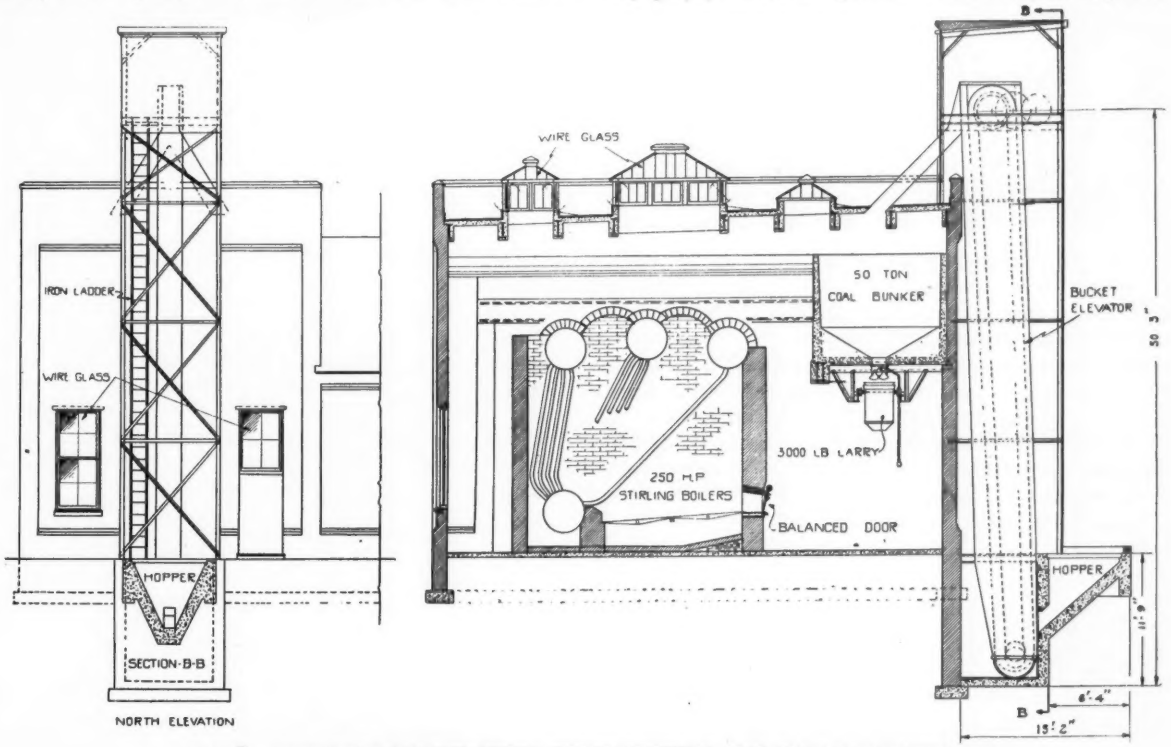


FIG. 5. ELEVATION OF NEW BOILER HOUSE SHOWING COAL HANDLING EQUIPMENT

It is almost needless to state that these conditions were not at all conducive to high efficiency. Scale in boiler drums was a constant source of trouble and the evaporation was low.

The installation of the Zeolite system has entirely eliminated all former difficulties due to scale, and has decreased maintenance cost to a great extent. In fact, the assistant manager of the plant stated that the system had paid for itself in 4 yr. through savings in coal, cleaning costs and other operating expenses.

This system has been in operation about 8 yr. and and has a rated capacity of 20,000 gal. of water per 24-

hr. day. The actual capacity is about 35,000 gal. In eight years they have replaced in all, about 250 lb. of the Zeolite material in the top layers of the filter. The salt consumption for regeneration of the filter averages about 300 lb. for 35,000 gal. of softened water. The

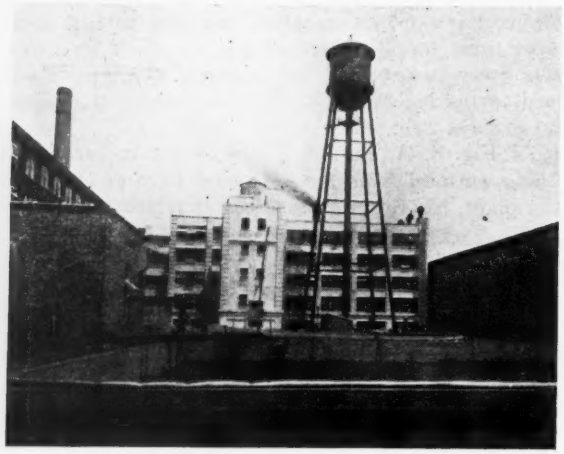


FIG. 6. VIEW OF WATER TOWER AND RESERVOIRS

hard water consumption for backwashing the filter is about 2300 gal. per day.

In connection with the softener, a clarifying filter of the sand bed type which cleans the water before passing into the Permutit softener is provided. The clarifying filter is also used to clean water for storage purposes (rain water and excess filtered water) used for boiler feed. A large storage cistern in the yard has a capacity of 100,000 gal.

Make-up water runs about 15,000 gal. per 24 hr. All returns are led into a hotwell completely insulated,

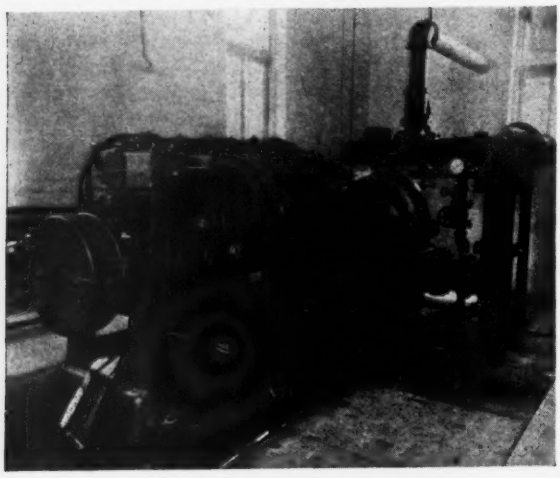


FIG. 9. GASOLINE DRIVEN FIRE PUMP

and covered, installed outside of the buildings where water is maintained at a temperature of about 150 deg. F. Water passes from the hotwell into the feed water heater and then through a pair of Deolizers.

These two Deolizers are provided to remove the oil in the condensate, which includes all returns from the pump and heating system, and each has a capacity of 26,000 gal. per 24 hr. These operate under a pressure of about 7 lb. with the water temperature at 212 deg. They are cleaned by back washing with hotwell water once every 24 hr., with a consumption of some 150 gal. of water during the 5 min. cleaning period. A small centrifugal pump is provided for washing pur-

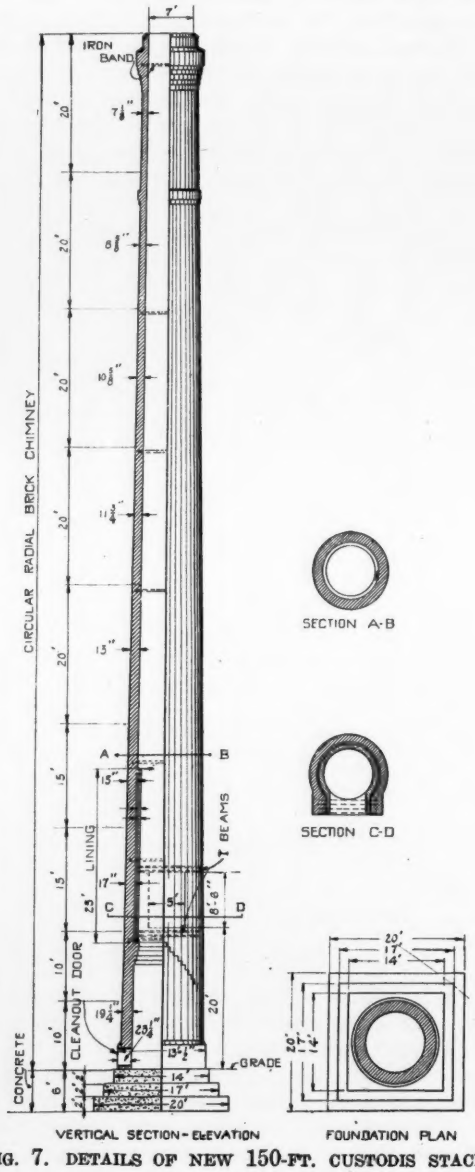


FIG. 7. DETAILS OF NEW 150-FT. CUSTODIS STACK

poses. The Oleite material in this installation is recharged twice yearly, calling for 2400 lb. semi-annually for both filters. The old or used material is reburnt and used again.

KILNS

DUE TO THE long period of air drying (usually 3 to 4 yr.) to which the lumber used in the making of the Steinway piano is subjected, the steam consumption on the dry kilns is greatly reduced over that which would be required for green stock.

Dry kiln equipment consists of two Nichols kilns of the platen type fitted with temperature and humidity

control apparatus with capacities of 8000 and 12,000 sq. ft. of 2-in. lumber. In addition, the latest type of National Dry Kiln Co.'s kiln handles 30,000 ft. of heavy size lumber on transfer cars and trackage. Five Sturtevant kilns of the older type are available for drying about 100,000 ft. of a variety of sizes, and a new Sturtevant kiln with 20,000 ft. capacity dries 3 and 4-in. hardwood.

All these kilns are heated by exhaust steam supplemented by live steam at night, and live steam only is used for heating warming boxes used in gluing wood, veneering, glue heaters, etc. Live steam is also used for plant heating at night and in extreme temperatures and for the engines in the power plant.

In a new and detached building of the factory, various woodworking machinery is run by electric motor from power purchased from the New York & Queens Electric Light & Power Co.

Compressed air is used throughout the mill floor for the cleaning of woodworking machines and is also used for cleaning motors, for spraying japan on piano plates and to some extent in the foundry on molding machines.

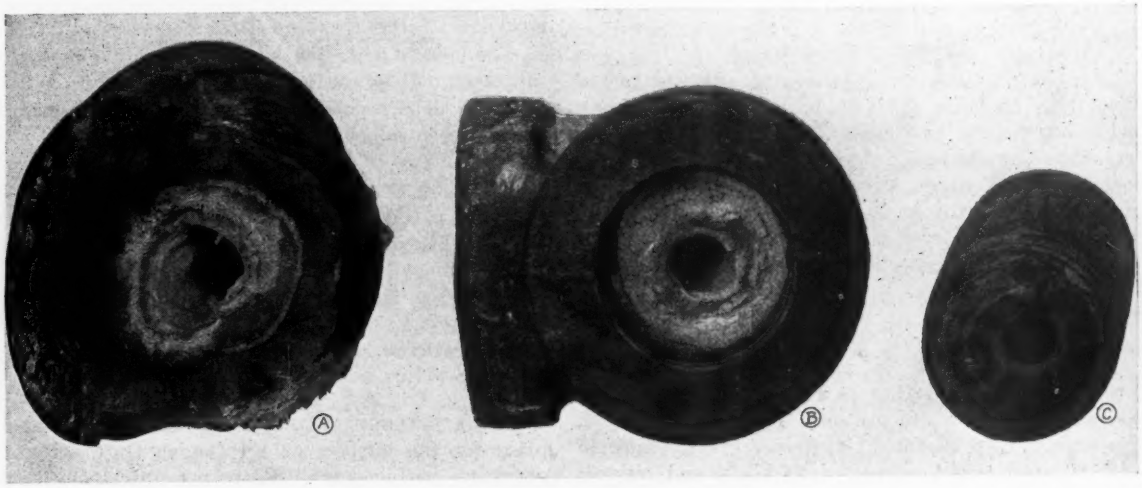


FIG. 8. SPECIMENS OF SCALE FORMATION TAKEN FROM LINES AT THE STEINWAY PLANT BEFORE INSTALLATION OF WATER SOFTENER

Exhaust Steam

Exhaust steam is used wherever possible for heating purposes, supplemented by live steam at night. It is used for all plant heating, including the foundry and brass foundry. This practice of heating the foundries contributes much to the comfort of the employes in cold weather, although in similar plants or industries usually no attempt is made to heat foundries. Exhaust steam is also used for the heating of dry rooms of approxi-

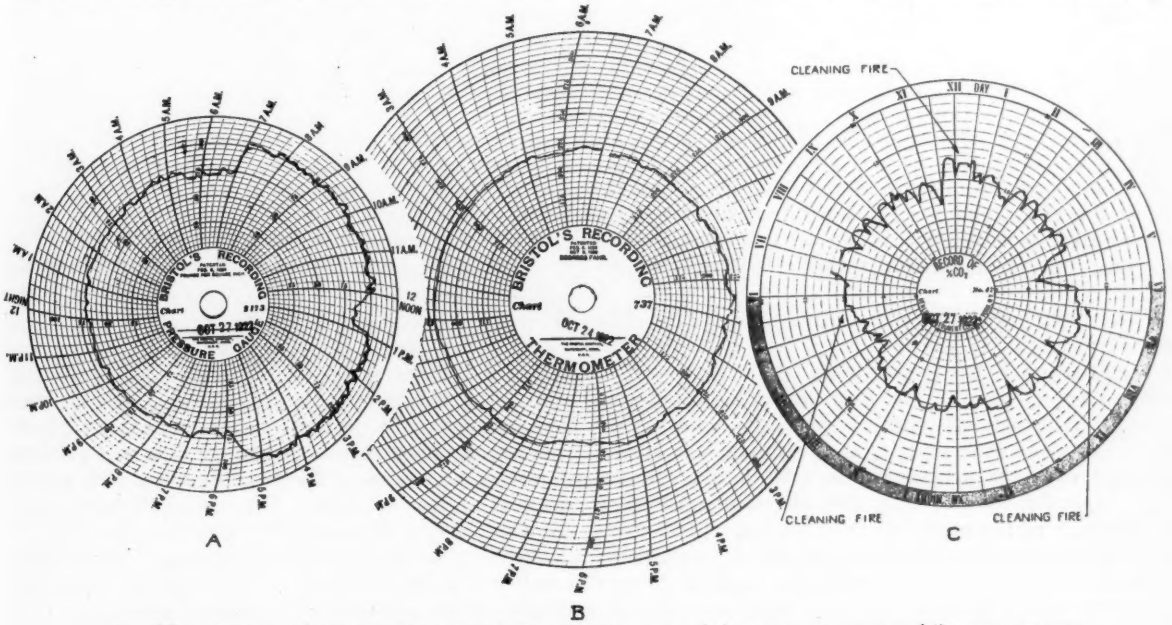


FIG. 10. TYPICAL CHARTS FROM RECORDING INSTRUMENTS (A) STEAM PRESSURE, (B) FEED WATER TEMPERATURE, (C) CO_2

mately 313,000 cu. ft. capacity, and the partial heating of dry kilns amounting to some 353,000 cu. ft. capacity, including ovens for bronzing and varnishing piano plates. The plant heating is partly by the Webster Vacuum System and partly by a gravity system.

Engine Equipment

The engine room which is located adjacent to the boiler room contains one 250-hp. Hewes and Phillips Corliss engine and one 250-hp. simple Corliss used as a standby. In addition to the equipment in the engine room there is a 40-hp. Metropolitan horizontal engine driving a line shaft in an isolated building with a 40-hp. vertical unit with Meyer automatic cutoff as a standby. There is also provided a 20-hp. engine for driving the blower in the foundry.

Fire Protection

At a plant where so much valuable lumber is stored and used, it is but natural that a thoroughly efficient and modern fire protection system is provided. This consists of a 50,000-gal. sprinkler gravity tank on a 125-ft. steel tower, connected to Wells and Newton dry and wet sprinkler systems using Grinnell sprinkler heads. To prevent freezing, the tank is provided with steam coils. This system is equipped with a 1500-gal. capacity sprinkler pump connected to a cistern having a storage capacity of 146,000 gal. of water.

The fire pump is unique in that it is driven by a four-cylinder, 175-hp. gasoline engine. It is a Lea-Courtenay unit and is self contained, that is, it is not dependent upon any outside source of power for its operation. There is also provided a 750-gal. duplex Worthington pump. This is connected to a system of standpipe, hydrants and to the sprinkler system, and takes water from Bowery Bay by means of a 14-in. water main. There are 12 hydrants in the yard with breakdown valves.

The above described fire protection equipment is supplemented by the company's own fire department. This fire department has proved exceedingly valuable and has been called upon for service a number of times, in at least one of which it prevented a serious fire on an adjoining property.

The 146,000-gal. cistern referred to in connection with the fire protection system is cross connected with the 100,000-gal. rain water reservoir mentioned in connection with the water supply system. This cross connection gives additional protection in case more water is needed for fire fighting.

Conclusion

An excellent system of records is kept at this plant for the purpose of keeping accurate account of operating performance. Steam pressure, temperatures, and furnace conditions are automatically recorded, and the data used to compile weekly and monthly cost sheets. A Uehling CO_2 recorder installed in the boiler room makes it possible to maintain combustion conditions at their best.

In concluding this description we wish to acknowledge our indebtedness to Steinway & Sons, for assistance rendered and privileges extended in the matter of collecting data used in the preparation of this article.

Uniflow Engine Principle and Design---I

A Discussion of the Thermal Advantages of the Uniflow Together With Some of Its Drawbacks. By Fred William Bosch

WITH THE GENERAL strife towards simplicity, increasing the effectiveness, and, above all economy, the technic of the last 12 yr. has developed a steam engine, which distinguishes itself by extraordinary simplicity in construction and such phenomenally low steam consumption as never attained before.

The name of the engine is derived from the flow of the steam as it passes through the cylinder, viz., the steam, after passing through the cylinder-heads, enters the cylinder at the ends and after cutoff and expansion have taken place, is expelled or exhausted at the opposite end, that is, at the end of the stroke, through exhaust ports arranged around the cylinder in the cylinder wall, forming the exhaust belt, so called and located at the center of the cylinder. These ports are uncovered and controlled by the piston, which, therefore replaces and has the function of the exhaust valve or valves.

In ordinary reciprocating engine, which is now more specifically known and designated as the "counterflow" engine in contrast to the "uniflow" engine, the steam returns on its path at the end of the stroke and is exhausted at the same end of the cylinder at which it entered, hence its name.

A further and more specific definition of the uniflow principle is expressed in the following two sentences:

(a) The steam, while exerting or giving up energy, is passing through the cylinder in substantially the same direction of flow, that is, without returning on its path.

(b) The steam-swept parts or surfaces come in contact but once with the same steam.

The last sentence represents the main characteristic and expresses the uniflow principle to its full value. The aim or most important factor is, to prevent the re-extraction of the heat imparted or given up to the cylinder surfaces by the incoming high-temperature and dry steam, which would result inevitably, were the steam, which, during the progress of the expansion continues to drop in temperature and gain in moisture, permitted to re-sweep the same surfaces. This aim is fully attained in the uniflow cylinder. The uniflow idea therefore, is principally concerned with the economic operation of the engine, that is, the all important factor of preventing the detrimental heat exchanges and the initial-condensation. That this detrimental source has always been fully appreciated by the designer in the past is plainly evidenced by the evolution of the steam engine.

Thermal Features

The main thermal advantage of the uniflow lies in the fact that the re-evaporation of the steam during the latter part of the expansion stroke and the heat necessary for this process is prevented as follows:

The difference between the temperature of the live steam admitted to an engine cylinder and that of the exhaust steam leaving it, makes the cylinder walls, cylinder heads and piston act as reservoirs of heat which

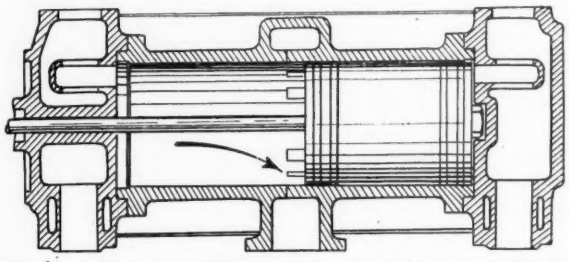


FIG. 1. DIAGRAM OF THE ORIGINAL AND TYPICAL UNIFLOW ENGINE CYLINDER

alternately fill and discharge at every stroke. The greater the ratio of expansion, the greater the difference in temperatures at the beginning and end of the stroke, and hence the greater the heat loss. This heat loss is commonly attributed to "initial condensation," and is by far the greatest loss in steam engines, but is almost entirely eliminated in the uniflow cylinder.

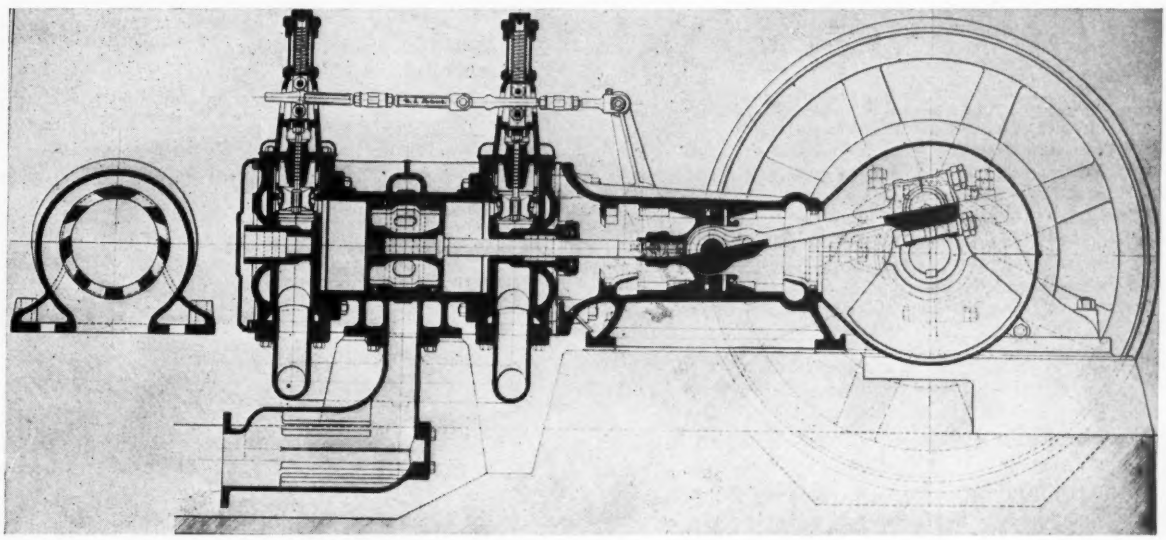


FIG. 2. SECTION THROUGH A 12 BY 12-IN., 300-R.P.M. UNIFLOW ENGINE

But this phenomenon is simply the evidence of heat being imparted to the cylinder to raise it to the temperature of the incoming steam. The abstraction of heat from saturated steam immediately causes condensation, which is followed by evaporation and cooling as the pressure falls.

The superior economy of the multiple expansion engine is, as we of course all know, due to the fact that the range of expansion is divided between two, three or four cylinders, but the temperature difference in each cylinder is not so great as in a simple engine working to the same number of expansions. In other words, for instance in a triple-expansion engine the high-pressure cylinder is hotter than the intermediate-pressure, and the intermediate-pressure cylinder is hotter than the low-pressure cylinder. If the whole range of expansion were effected in one cylinder, its temperature would be an average between that of the live or incoming and the exhaust steam.

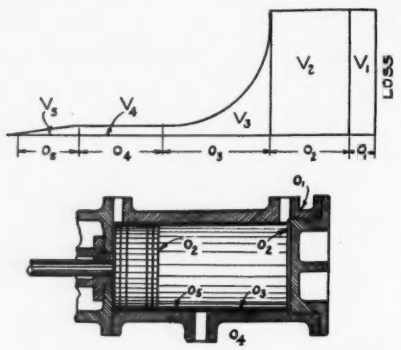
In theory, therefore, the greater the number of cylinders, the higher the efficiency, but mechanical losses set a practical limit to the number of cylinders, four being as many as it is profitable to use, which of course is practicable only in the largest sizes. It is in this respect that the steam turbine is at a great advantage over the reciprocating engine; the zones of temperature can be graded by very fine differences, thus reducing losses from heat interchanges to a minimum. The Parsons turbine is really an expansion nozzle, hot at one end and relatively cold at the other.

Much ingenuity has been expended on steam engine design to reduce the heat losses in simple engines and make their performance approach more nearly in economy that of multiple expansion engines. The problem was, to do in one cylinder what is usually done in two, three, or even four cylinders, and tackling this after the manner of the steam turbine resulted in the uniflow engine, where the steam enters hot at one end and leaves relatively cold at the other end through the exhaust belt. The facts and fundamental thermal theories undoubtedly were Stumpf's guiding lights, rather than former inventions or old patents. The principles are: "Cutoff early," "Use a large ratio of expansion," "Keep the hot end hot and the cold end cold." While the increased efficiency is probably primarily due to the non-reversal of flow of the steam, the admission ends thus remaining hotter, and partly due to the reduced time of exhaust, yet, considerable credit should go to the hollow cylinder-heads in which the live steam circulates and as is plainly evidenced by the remarkable economy obtained by the "Van den Kerchove" engine, which uses this arrangement and also has the admission valves located in the hollow cylinder heads, thereby reducing the clearance volume.

In the Stumpf engine, the steam entering the cylinder is practically even heated somewhat by the compression charge, which is of extremely high temperature. During the adiabatic expansion, condensation

occurs to such an extent that at the end of the stroke the steam contains a great deal of moisture, with the exception, however, of the portion nearest to the steam-heated cylinder heads, which is kept dry if not even in a slightly superheated condition by radiation from that source. The steam following nearest the piston is in contact with the coolest surfaces and therefore contains the highest percentage of moisture, the more so as here the cylinder wall is of still lower temperature and absorbs some of its heat to return it later during the compression.

During the period of exhaust, the uniflow engine expels the coldest steam, which contains the largest amount of moisture, retaining the driest portion for compression,



The above illustration and diagram shows the detrimental effect of unit surfaces for Uniflow cylinders. The losses apportioned to the cylinder walls through the unit surfaces V_3 to V_5 are very small. If account is taken of the important influence of the steam flow on the heat loss through the walls, especially in the passages, the advantage of separating the exhaust channels from the live-steam space becomes more apparent, as does also the importance of reducing of V_2. The above cyl. was constructed for laboratory work and especially for high superheat and for that reason was wholly unprovided with jacket heating of any kind.

FIG. 3. DIAGRAM SHOWING DETRIMENTAL EFFECT OF UNIT SURFACES FOR THE UNIFLOW CYLINDER

in contrast to the ordinary counterflow engine in which the hottest steam, that is the most desirable portion, passes out through the exhaust, carrying along the heat of the hot surfaces it strikes when leaving the cylinder and leaving besides a moisture or water film behind. The cylinder walls are exposed to the exhaust temperature for about 85 per cent of the time required for the return stroke, whereas in the uniflow engine the exhaust period is much less, this again being particularly so of the true uniflow engine, where the exhaust is from 10 to 12 or 13 per cent of the stroke.

Figure 1 is a sectional view of the original and typical true uniflow cylinder, which is very simple indeed, however, it will be noted that the compression commences unusually early, which is one of the typical features, and we may say, necessary evils, of all center-discharge engines; the compression usually extends over 88 to 90 per cent of the stroke. The steam remaining in the cylinder on the return or exhaust stroke, after the exhaust ports are closed by the piston, is trapped and compressed in the clearance space to live steam pressure or any predetermined compression pressure. This feature of the cycle, while apparently economical, is not so, thermodynamically, for the reason that the power required to compress has been generated in a comparatively low efficiency cycle and the resulting available energy in the compressed steam is far below that required for its compression. But mechanically this feature is unavoidable for two reasons, the first being the very structure of the typical or true uniflow cylinder and secondly the need of cushioning effect in the cylinder, especially of high-speed engine, to check the momentum of the reciprocating masses, preventing shock and noise, a common requirement, of course, in all reciprocating engines, but requiring particular care in this type of uniflow on account of the heavier reciprocating masses. Yet on account of the high compression, a great piston-speed is possible in spite of the extremely heavy reciprocating parts, which according to Prof. Stumpf should be preferably 800 to 900 ft. per min.

In summarizing the distinct advantages derived from a uniflow engine, we find:

(a) Simplicity of valve gear and reduced friction;
(b) Large overload capacity;
(c) Flat steam consumption curve through various ratings;
(d) Reduced piston leakage and no exhaust valve leakage;
(e) Poppet valves permitting use of very high superheat without complications;
(f) Mechanical simplicity;
(g) High revolutions and great piston-speeds possible;
(h) Less floor space required;
(i) Simple foundation;
(k) Less care and attention;
(j) High over-all efficiency;
(l) General application;
(m) Remarkably low, in fact, lowest steam consumption because of great reduction of cylinder condensation and re-evaporation;
(n) Consequent to the foregoing, smaller investment in boilers, stokers, chimneys, etc.

Disadvantages

When an invention has so many advantages as just cited, it is hardly possible that not a few drawbacks are attached to it. In the "true," two-valve uniflow engine, in other words, in the exhaust-valve-less engine, to the great inertia forces of the reciprocating parts and the extraordinary large clearance necessary for the successful operation of non-condensing engines of this type, may be added its enormous maximum piston pressure per horsepower, which necessitated the design of extremely heavy parts. It may be compared with the low pressure parts of a compound and even triple expansion engine able to withstand live steam pressure, of course, necessitating a heavy construction throughout, to develop the energy of the two or three cylinders combined, requiring extra large bearings. In addition to this feature, the piston and correspondingly the cylinder are abnormally long, which also is a feature or necessary evil of all center-discharge engines, as a matter of fact, the length of the piston equals the stroke minus the length of the center-exhaust slots, the latter usually being from 10 to 12 per cent of the stroke, and this means practically a piston three times the ordinary piston length of the old counterflow engine.

(To be continued.)

Comparing Value of Power Plant Fuels

GRAPHIC METHOD OF COMPUTING COST OF STEAM GENERATED WITH OIL AND COAL AS FUEL. BY G. MILTON LEVY.

DURING the recent coal strike, the eyes of the industrial world turned to fuel oil as the logical successor to coal. As a fuel it has much to recommend it. The supply is large; it is universally available; is easily stored in tanks as compared to the large yard space required for a coal pile. Oil can be burned with high efficiency and with decreased fire room personnel, due to the elimination of the coal and ash handling crews. It is easy to handle and is clean. There are no ashes to be removed and no dust to work its way through the entire plant. These are some of the advantages that are advanced in favor of oil over coal as a fuel.

The initial cost of installation in an oil burning plant is the main cost. There is little or no upkeep or repair cost as compared to the continual maintenance in stoker equipped plants.

These are all general statements and one desires facts and figures as to the relative operating costs of coal and oil fired boilers. Which fuel should be used to produce steam at the lowest possible figure? At what point is it cheaper to burn oil than coal, or vice versa? These are the ultimate questions that must be answered clearly before a change in equipment can be authorized.

Let us take a plant generating 10,000 lb. of steam per hour at 150 lb. per sq. in. pressure from feed water at 212 deg. With oil as a fuel, an efficiency of 75 per cent can be obtained and with coal, 60 per cent is a fair figure. Let us further assume a cheap grade of coal, having 10,000 B.t.u. per lb. and oil having 18,650 B.t.u. per lb.

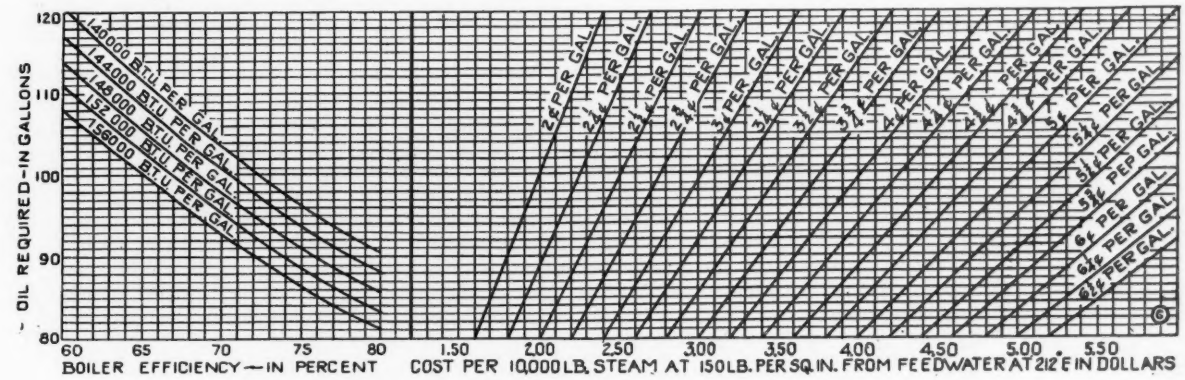


FIG. 1. CHART FOR DETERMINING COST OF STEAM WITH OIL AS FUEL

To evaporate the above-mentioned quantity of water under the given conditions would require (10,000 × 1.0443 × 970.4) 10,129,710 B.t.u. per hour and at 60 per cent boiler efficiency it would be necessary to burn

$$\frac{10{,}129{,}710}{0.60 \times 10{,}000}$$

or 1688 lb. of coal per hour or 0.754 ton of 2240 lb. per ton.

Similarly the oil required would be

$$\frac{10{,}129{,}710}{0.75 \times 18{,}650}$$

or 724.2 lb. of oil per hour, or at 8.32 lb. per gallon this would be 86.9 gal.

Now if our coal cost $4 a ton of 2240 lb. delivered (this is a figure for poor grade anthracite), the steam

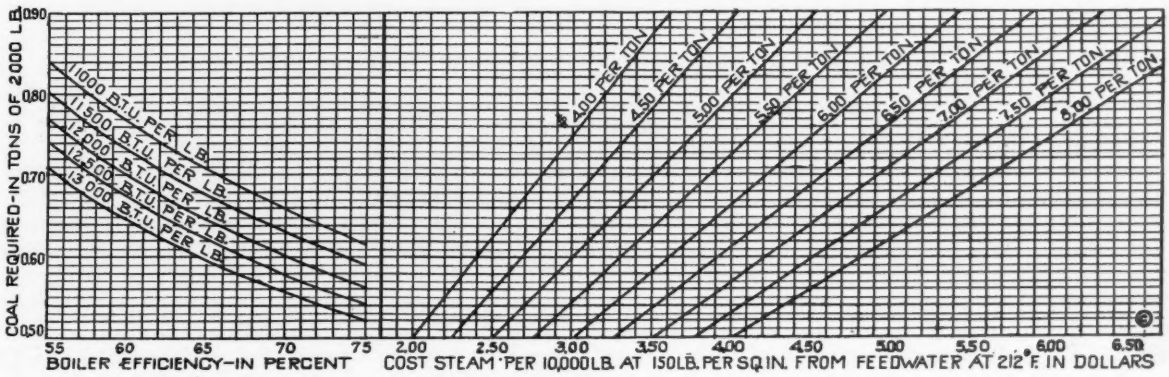


FIG. 2. CHART SHOWING STEAM COSTS FOR VARYING EFFICIENCIES, HEAT VALUES AND COAL COSTS —USING 2000 LB. PER TON

would cost $3.02; while with oil at, say, $0.035 per gal. delivered, our cost of steam would be $3.04.

It is at this point that the actual cost of firing the fuel must be taken into consideration; i. e., what charges are made against the boiler house for repairs, for labor of handling fuel and disposing of waste for each unit of fuel fired? And how will these charges vary should the plant be changed from coal to oil?

If after all charges have been made, it is found that it costs less than $1.50 per ton of coal when stoker fired and $2 per ton when hand fired, then the operator is to be congratulated. Therefore it becomes necessary to revise the cost figures obtained above and the total cost of coal becomes $5.50 per ton of coal burned. At this rate the cost of steam becomes $4.14 per 10,000 lb.

Oil can be fired for $0.005 per gal. and this would bring the total cost to $0.04 per gal. burned, or $3.48 per 10,000 lb. of steam generated. Thus a saving of $0.66 would be effected for each 10,000 lb. of steam generated, when burning oil under the above conditions.

Now, this is merely a sample case worked out to show the method used in calculating the accompanying curves. In order to use these curves, it is necessary to have the following data: (1) the efficiency at which the boilers can be operated with coal and with oil, (2) the heat value of the coal and of the oil and (3) the firing costs; that is, the actual cost of firing the fuel which includes labor and maintenance.

For example: An oil salesman offers you fuel oil at $0.04 per gal. and this oil has a heat value of 18,900 B.t.u. per lb. Is it advisable to change from coal which you are now using? Is the salesman offering you an opportunity of saving money on your steam costs? It surely is worth while examining the offer so that the foregoing questions can be answered to your own satisfaction.

You know that your particular plant is operating on No. 3 Buckwheat which you buy for $2 a ton at the mines, the freight is say $2.50 a ton, making the cost $4.50 a ton per ton delivered. From your operating cost records you should be able to determine the total cost per ton of coal fired, which is, let us say, $6. This means that it costs $1.50 for labor and repairs for each ton of coal burned and further you know that your year in year out boiler efficiency is 62.5 per cent and that your coal has a heat value of 10,500 B.t.u. per lb.

Now, with this information at hand, we are ready to use the charts. Enter the coal chart at 62.5 per cent efficiency and from where the efficiency line cuts the curve of 10,500 B.t.u. per lb., proceed to the right to intersection with curve of $6 coal, then drop perpendicularly and read $4.15 as the cost per 10,000 lb. of steam.

With oil as fuel, you can get a higher efficiency from your boilers and 75 per cent is not an uncommonly high figure, so we will use it here. Enter the oil chart at this efficiency and from where the efficiency line cuts the curve of 18,900 B.t.u. oil, proceed to the right until this line intersects a line drawn perpendicularly up from $4.15. This intersection will

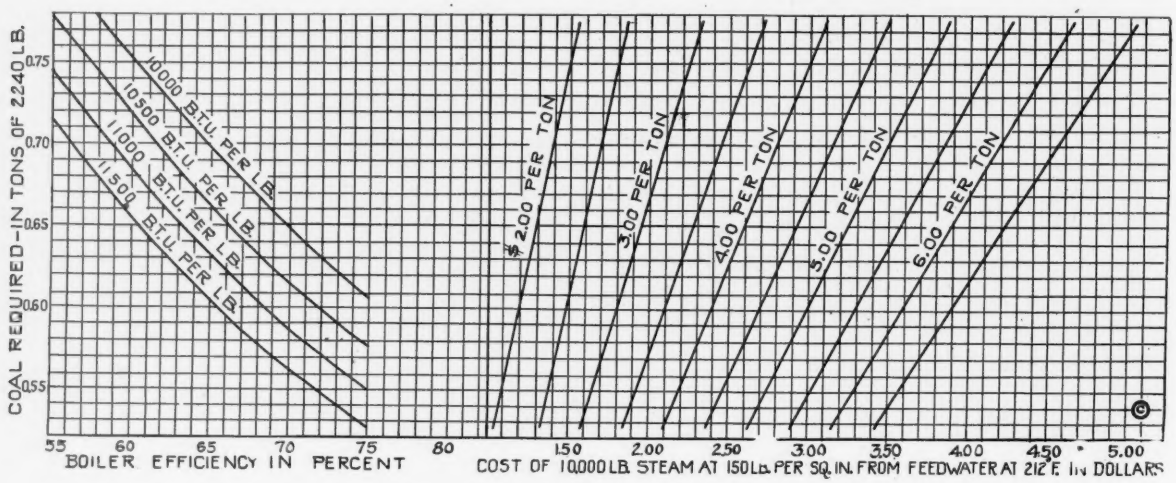

COAL REQUIRED—IN TONS OF 2240 LB.
0.75
0.70
0.65
0.60
0.55
10000 B.T.U. PER LB.
10500 B.T.U. PER LB.
11000 B.T.U. PER LB.
11500 B.T.U. PER LB.
$2.00 PER TON
3.00 PER TON
4.00 PER TON
5.00 PER TON
6.00 PER TON
55 60 65 70 75 80
BOILER EFFICIENCY IN PERCENT
1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00
COST OF 10,000 LB. STEAM AT 150 Lb. PER SQ. IN. FROM FEEDWATER AT 212° F. IN DOLLARS

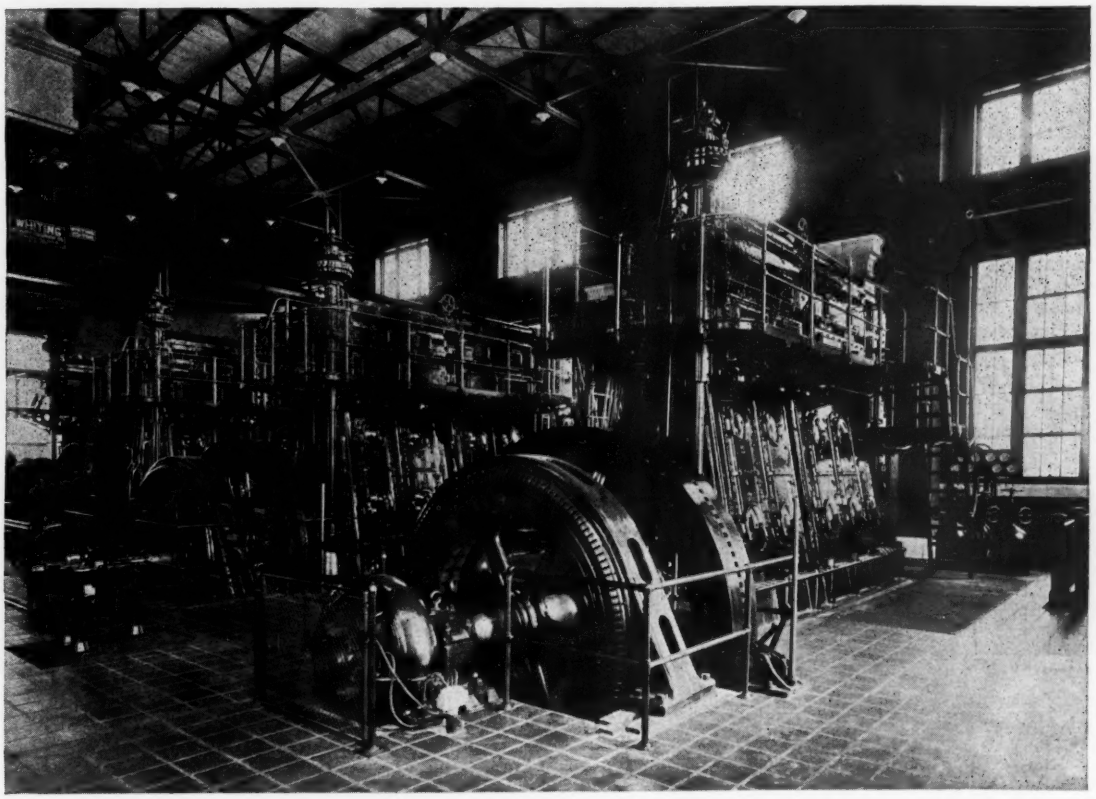
FIG. 3. CHART SHOWING STEAM COSTS FOR VARYING EFFICIENCIES, HEAT VALUES AND COAL COSTS —USING 2240 LB. PER TON

give the total amount that you can pay for oil, namely, $0.0465 per gal.; but your firing costs will be about $0.005, which means that you could afford to pay $0.0415 per gal. and still make steam for the same figure. The salesman has offered you oil at $0.04 per gal. You have found that you can make a saving by using this oil, but what will it amount to?

By again referring to the curves, you will find that by using this oil steam will cost $4.05 per 10,000 lb., or a saving of $0.10 on this quantity of steam. Now, knowing your hourly steam output, it is comparatively simple to determine the annual saving.

Thus the answers to all questions asked are readily found and the only remaining factor to be determined is whether the saving effected by the use of the oil will pay for the initial installation. This is a question which must be answered by the executive and his engineers; but it will generally be found that where a real saving in the generating costs can be shown, the conversion of the plant from coal to oil will be a step well worth taking, as has been found in many plants which are now using fuel oil economically.

Chicago Sanitary District Chooses Diesel Plant for Stand-by



THIS SUMMER the Chicago Sanitary District placed a 2500-kv.a. Diesel engine plant in operation after a careful consideration of the type of prime mover best suited to the operating conditions. The Sanitary District gets power from its hydroelectric plant on the drainage canal at Lockport, Ill.; but as this power comes in over a transmission line some 30 mi. in length, it was thought advisable to have a reserve plant at the sewage pumping station.

Investigation showed that a Diesel plant would cost about 10 per cent more than a condensing steam turbine plant but would have the advantage that the annual charges would be only one-third of those for a steam plant. This low cost for stand-by service is due to the fact no fuel is required unless the Diesel plant is running. Moreover the units can be placed on the line quickly, the units are self-contained, and a high thermal efficiency is secured under varying load conditions. Many unusual features have been incorporated in the layout of this plant. Each cylinder is fitted with a thermo-couple so that the exhaust temperature may be read on a pyrometer as a check on the division of load; preheaters for fuel oil are installed in the exhaust lines; sewage is used in a heat exchanger to regulate the temperature of the soft water which cools the engines; and the engine governors are equipped with motor operated speed regulators for paralleling and shifting of load at the switchboard.

Four 750-b.hp., 180-r.p.m. Busch-Sulzer vertical two stroke cycle, type C, Diesel engines, each direct connected to a 625 kv.a. 60-cycle, three-phase, 2300-v. General Electric Co. generator, make up the power units. The generator, flywheel and 16-kw., 125-v. exciter are mounted on an extension of the engine shaft.

Commercial Economy of High Pressure and Superheat*

EFFICIENCIES OBTAINABLE AND MATERIALS AVAILABLE FOR USE WITH STEAM AT EXTREME LIMITS OF PRESSURE AND TEMPERATURE. BY GEORGE A. ORROK.

OUR engineers are now using better and more uniform materials than ever before. Our metallurgical and manufacturing methods have been greatly improved. Copper, wrought iron, and cast iron have been discarded for boiler purposes. Steel and even alloy steel are in common use and their uniformity leaves little to be desired. Certain of the non-ferrous alloys are in common use and play their part in aiding the common security which characterizes modern installations. Copper boilers and 212 deg. maximum temperature gave place to wrought-iron boilers and 30 to 40 lb. pressure with a maximum temperature of 300 deg. The use of steel as a boiler material raised the pressure to 200 lb. and the temperature to 400 deg., with a maximum temperature of 750 deg. In certain distillation plants temperatures as high as 1100 deg. have been obtained, but the life of the material is short.

Now, it is well known that steel when heated to comparatively low temperatures, say, 900 or 1000 deg., loses its strength and becomes unfit to sustain loads,

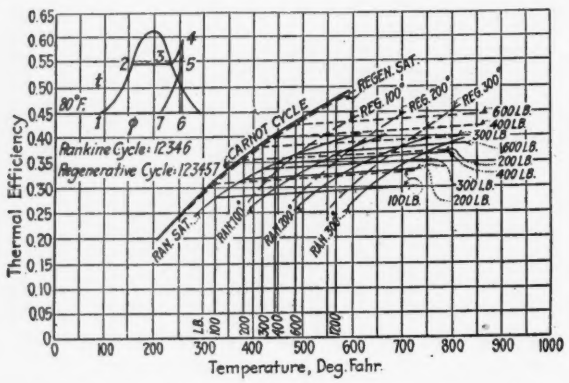


FIG. 1. THEORETICAL THERMAL EFFICIENCY OF THE CARNOT CYCLE, THE RANKINE CYCLE AND A REGENERATIVE CYCLE, USING BOTH SATURATED AND SUPERHEATED VALUES, FOR RANGES UP TO 1200 LB. AND SUPERHEATS OF 750 DEG. AND ABOVE

and the heat strains from even moderate heating of 300 or 400 deg. may cause certain deformations of a highly unsatisfactory character. Cast-steel valves have deformed at 750 deg. to such an extent as to render them useless, and the "growth" of ordinary cast iron at temperatures above 450 deg. is known to be destructive; but notwithstanding this the later constructions at 250—300 lb. pressure and 700 deg. maximum temperature are commercial. The first cost is not excessive, repairs are moderate, and the life of the installation is all that can be desired.

COMMERCIAL LIMITS OF PRESSURE AND SUPERHEAT

WHAT, then, are the commercial limits of pressure and superheat in the central station? In Fig. 1, we have calculated and plotted the theoretical thermal efficiency of the Carnot cycle, the Rankine cycle, and a regenerative cycle, using both saturated and superheat values for ranges up to 1200 lb. and superheats of 750 deg. and above. It will be seen that the chosen regenerative cycle for saturation follows very closely the efficiency of the Carnot cycle, while the Rankine cycle falls below the Carnot cycle increasingly with rise of pressures. The superheat lines for both cycles are nearly parallel and maintain this characteristic over a wide range. The gain from regeneration increases with pressure and is constant for equal superheat. For any final temperature, the gain from pressure increments decreases, but the gain from regeneration increases with pressure increments. Thus at 750 deg. final temperature, the Rankine efficiency increases from 33.5 per cent to 40.5 per cent with pressure rise from 200 to 1200 lb., while the regenerative efficiency increases from 37 per cent to 48.5 per cent with the same pressure increase.

TABLE I. SAVINGS EFFECTED THROUGH INCREASE IN STEAM PRESSURE

Case	Cycle	Pressure, lb.	Max. temp. deg. fahr.	Theoretical efficiency, per cent	Station efficiency, per cent	Actual effic ncy, per cent	B.t.u. per kw-hr.
1	Rankine.....	200	750	33.5	55	18.4	18,500
2	Rankine.....	1200	750	40.5	55	22.3	15,300
	Saving.....			21			3,200
3	Regenerative,	200	750	37	55	20.35	16,800
4	Regenerative.	1200	750	48.5	55	26.7	12,800
	Saving.....			33.3			4,000

Figure 1, dealing with theoretical efficiencies only, does not show the station losses which aggregate around 45 per cent. Grouping the losses, we may say that the generator efficiency is 97 per cent, turbine efficiency 78 per cent, boiler efficiency 80 per cent, leaving for auxiliaries, piping, and radiation 97 per cent, all of which multiplied together give 55 per cent efficiency.

Table I shows how these figures work out for the foregoing suppositions. The saving by regeneration when using 200 lb. pressure (Case 1—Case 3) is 1700 B.t.u., and when using 1200 lb. pressure (Case 2—Case 4) is 2500 B.t.u. Considering the trend of the curves in Fig. 1, comparatively little is gained by further superheating, but there has been no attempt to go above 800 deg. and the flattening out is much more marked as the temperature increases.

Water has its critical temperature at 704 deg. and the critical pressure is about 3200 lb. Pressures up to this limit may therefore be considered, and since oil-still temperatures up to 1100 deg. have been used, we may consider superheat temperatures up to that point. We know that the first allotropic change in steel occurs at about 1300 deg., and 1100 deg. is well below this point. Here, however, we must look into the physical properties of the steels used in power-plant construction.

When steel is heated, the first sign of change—a full red just visible in the dark—appears at about 750 deg. Visibility in daylight begins at about 850 to 900 deg. and a full dark red is attained at about 1100 deg.

*Abstract of paper to be presented at the Annual Meeting, New York December 4 to 7, 1922, of the American Society of Mechanical Engineers.

The full cherry red is attained at the first allotropic change of 1300 deg. Good boiler steels increase in tensile strength up to about 600 to 700 deg. and lose much in ductility, but above 800 deg. the tensile strength rapidly falls off and the ductility largely increases. Cast steels of proper carbon content and suitable for fittings, valves, and turbine construction show the same properties within rather narrow limits. Pipe steels have nearly the same characteristics, but the temperature at which the tensile strength starts to fall is around 550 to 600 deg. This lack of ductility or increase in brittleness at the maximum temperatures of use must be compensated for by a larger factor of safety (i.e., increased thickness and weight with higher cost) and a more careful selection of material. But with increased thickness it must not be forgotten that the safe stresses must be correspondingly lowered.

Variation of Strength of Materials with Temperatures

This subject may be considered from five points of view, depending on the conditions under which the materials are to be used.

(a) Boiler Material. Here we know that the maximum temperature cannot exceed 704 deg., the critical temperature of water, and that the fire side of the tube or drum can only be a few degrees hotter. If 1200 to 1800 lb. per sq. in. be the chosen pressure, the water temperature is 625 deg. at maximum and the fire side will not exceed 725 deg. normally. This temperature is well within the maximum-strength zone, and only care is needed to secure sufficient ductility.

(b) Superior Material. The maximum temperature of the inner surface of the tubes may be a little higher than the maximum superheat. The outer temperature depends on the position in the boiler. Radiant-heat superheaters are now commercial where the pressure parts are protected with a heat-absorbing and conducting covering of cast iron. The fire surfaces may be 1400 deg. to 1600 deg. while the inner-wall temperature is as low as 700 deg., but 1100 deg. is comparatively easy of attainment. Bare-tube superheaters would have a maximum outside temperature of around 1200 deg., but the life at this temperature is unknown. The maximum safe point may be taken as 800 deg. superheat temperature and 950 deg. outside temperature.

Neither the tube manufacturers nor superheater manufacturers are afraid of these conditions, and I believe they are prepared to guarantee their product under such conditions.

(c) Piping Material. Under this category the condition is markedly different. The steam of the pipe is below the maximum temperature of the steam. The outer surface is much lower and the thickness of the material can be increased to compensate for the lower elastic limit of the material. The ductility is improving with temperature increase. Pipe joints are the only serious trouble, and the modified Van Stone joint with the pipe edges welded for tightness is the apparent solution. Experience with this joint has been satisfactory.

(d) Valves and Fittings. Valves and fittings must necessarily be made of castings, and the low-carbon, open-hearth steel used, while falling off in strength sooner than the worked material used in boiler and piping, has still a respectable elastic limit at 1100 deg. As in the last category, the inside-wall temperature is lower than the steam temperature, with still lower temperature at the outer wall. But the shape of the casting is all-important. Globe valves of the double-beat or Wanick type can be made with practically no flat surfaces and with two axes of symmetry. Internal pressures do not seriously deform this design, but external strains may cause minor troubles. Throttle valves and marine stop valves are usually of this type and can be kept tight at 750 deg. It is probable that a temperature of 1100 deg. could be safely undertaken with these valves if special precautions were used in the design of the seat, disc, and stem. Flexible-disc, double-beat valves are used in Europe at temperatures in excess of 750 deg.

Gate valves have only one axis of symmetry and flat surfaces of considerable size. Here seat and disc troubles are encountered at temperatures above 700 deg. and it may be some time before the manufacturers can guarantee a tight job at the higher temperatures. This type of valve is peculiarly sensitive to outside strains tending to deform the seats and disc.

(e) Turbine High-Pressure Ends. Pressures can make little difference here as the high-pressure parts are comparatively small and without doubt the pressure will be reduced 50 per cent in the first nozzle. There need be no high-pressure stuffing box, so that the highest pressure to be packed against will be about half the maximum. Temperature strains will be the only thing that need be considered, and the expansion will reduce the superheat in the first-stage nozzle to a workable value, which is 750—850 deg. It is to be noted that steam-chest or nozzle-box troubles have been the only prominent troubles where 400 lb. and 750 deg. superheat have been tried out, and it thus appears that a proper design will obviate most of the trouble. Cast or forged steel must be the material used.

In general, the turbine designers say that 1200—1500 lb. pressure has no terrors for them and can be used when desired. They can supply the apparatus. Temperatures are more troublesome and nobody apparently cares to go much above 700—750 deg. at the present time. Superheater and valve materials at present seem to be the deciding factor in the use of high pressures and temperatures, and there is apparently very little which careful design and the selection of proper materials will not overcome.

Only a portion of the central-station installation is affected by high pressures and temperatures, especially where electric auxiliaries are used. The boiler and piping system and prime mover cover about 40 per cent of the entire installation cost. Latterly, with the larger station the percentage is around 30, and may be taken at 25 per cent for the newer and larger stations of which Hell Gate and Calumet are types. If the station cost be taken at $100 per kw. as an average figure this portion of the installation has cost $25, and at 15 per cent the fixed charges are $3.75 per year or on 5000 hr. use 0.07 cent per kw.-hr. What, then, will be the extra cost of this apparatus when designed for higher pressures and temperatures? Standard boilers today can be bought up to 275 lb. pressure; 300 lb. necessitates thicker plates and tubes, and prices advance accordingly. 400-lb. boilers have been purchased

recently and 500-lb. boilers have been built. Flash boilers of the Serpollet and De Laval types using pressures in excess of 1200 lb. and coil boilers of the Herreshoff type using equally high pressures have been built as experiments or in toy sizes as for automobile work or for high-speed launches. Schmidt's water-tube boiler working at 900 lb. has been run 14,000 hr. with marked success. Boilers for 400 lb. pressure have been offered at about 50 per cent increases in price and 1200 lb. boilers have been figured at a 100 per cent increase.

Turbine designers are at work on designs arranged to utilize higher pressures, but higher temperatures seem more troublesome to them. I have no estimate, but we can safely apply the same percentage increases of price to the turbine that obtain with the boiler. Steam piping increases in size with increasing pressure, so much so that it is doubtful if a 1200-lb. steam line would cost more than a 200-lb. line of the same capacity. The volume of high-pressure steam at 1100 deg. maximum temperature is quite uncertain, but the chances are that our figures are not more than 10 per cent from the truth.

Summary

We may then summarize as follows:

(a) Pressures up to 1200—1500 lb. at least are commercial and may be attained without serious difficulty.

(b) Temperatures for the present are commercial up to 700—750 deg., which should not be exceeded until our materials for valves and superheaters are improved.

TABLE II. SAVINGS IN COAL

Pressure lb. per sq. in.	Superheat temp., deg. fahr.	Carnot effy.	Reg. effy.	Rank. effy.	Reg. × 0.55	Rank. × 0.55	Reg. B.t.u.	Rank. B.t.u.	Saving over R. 200 lb. 700°, B.t.u. per kw-hr. Reg. C.	Saving over R. 200 lb. 700°, B.t.u. per kw-hr. Rank. C.	Saving in lb. coal per kw-hr. (13800 B.t.u.) Reg. C.	Saving in lb. coal per kw-hr. (13800 B.t.u.) Rank. C.
200	700	53.5	37	33.4	20.3	18.35	16820	18620	1800	—	0.13	—
400	700	53.5	41.2	36.3	22.6	19.95	15100	17120	3520	1500	0.255	0.109
600	700	53.5	43.5	38	23.9	20.9	14300	16350	4320	2270	0.313	0.1645
1200	700	53.5	47.5	40	26.1	22	13100	15500	5520	3120	0.40	0.226
200	1000	63	38	35	20.9	19.25	16350	17750	2270	870	0.165	0.065
400	1000	63	42.8	37.6	23.5	20.7	14500	16500	4120	2120	0.299	0.1535
600	1000	63	45	39.5	24.7	21.7	13820	15720	4800	2900	0.348	0.21
1200	1000	63	49	41.5	26.9	22.8	12700	14970	5920	3650	0.43	0.257

More extended experience is necessary before the range of 800 deg. and over is attempted in a commercial installation.

(c) With the completion of the Steam Table Research it will be possible to calculate accurately just where the possible limits of economy in pressure and temperatures may be located. At the present time the uncertainty of all values above 200 lb. pressure and 400 deg. F. temperature renders most of our calculations of only academic value.

(d) There still appears to be more economy in a closer study of operation and construction losses—resulting in improving the efficiency of central stations installed in accordance with the present canons of design—than in the attempt to increase widely the temperature range of our heat cycles. While we may save 400 B.t.u. per kw.-hr. by using a regenerative cycle and increasing pressure and temperature, it should be possible to save nearly as much by a reduction to the lowest limits of the heat losses which we know exist in our present installations.

Savings of Regenerative Cycle

In table II we have given for 700 and 1000 deg. maximum temperature and for four pressures the theoretical efficiency of the three cycles used, the practical efficiency of the Rankine and regenerative cycles, and the savings per kilowatt-hour for all conditions over the Rankine cycle at 200 lb. and 700 deg. maximum temperature in B.t.u. and lb. of coal of 13,800 B.t.u. content.

In Fig. 2 these savings are plotted in cents per kilowatt-hour on the basis of $6 coal, together with the extra-fixed-charges curve. At the top of the figure are two curves showing the percentage increase in cost of boiler and turbine and the decrease in size of pipe required for a given quantity of steam. It will be seen that the extra fixed charges are always greater than the coal saving for the Rankine cycle (ordinary operation) at 700 deg. maximum temperature, and that

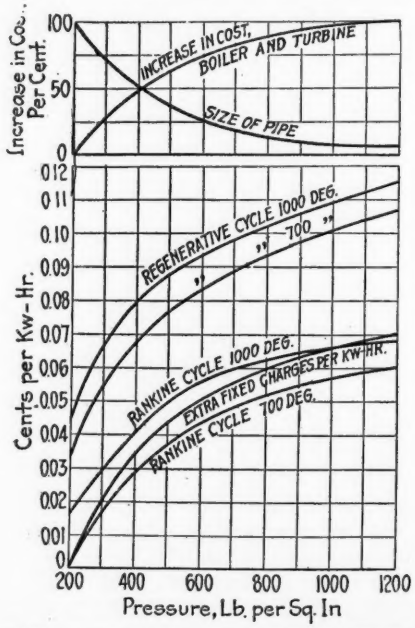
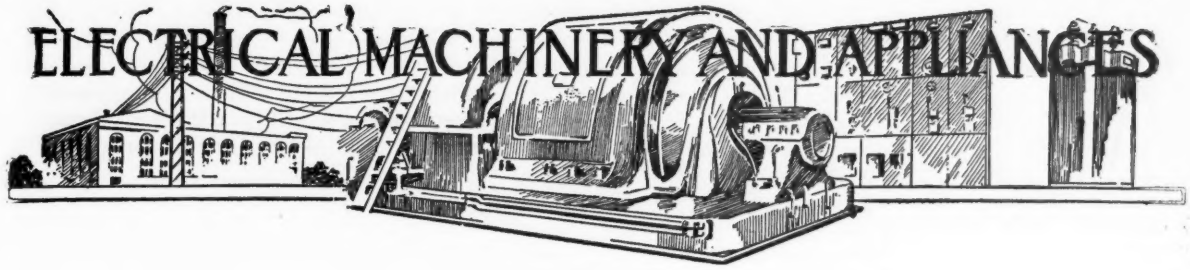


FIG. 2. SAVINGS IN CENTS PER KILOWATT-HOUR FOR ALL CONDITIONS OVER THE RANKINE CYCLE AT 200 LB. AND 700 DEG. MAXIMUM TEMPERATURE, BASED ON $6 COAL

the additional gain for the 1000 deg. maximum temperature barely exceeds the additional fixed charges. We cannot then expect much from increasing pressures and the ordinary methods of using steam. Increasing temperatures help to some extent, but not enough to be attractive, since the saving is nearly all used up by the additional fixed charges.

With the regenerative cycle the results are much better and useful savings are indicated, increasing considerably with pressure and slightly with temperature. It is evident that some such regenerative cycle must be used, but the rewards from increasing temperature are not commensurate with the costs. Many regenerative cycles are possible, but the one used shows nearly the maximum economy. Such cycles need many heat interchangers and a number of separate feed pumps for the close approach to theoretical figures. Indeed, Thurston and Stanwood in 1899 pointed out that with an infinity of heaters and pumps the Carnot efficiency might be equaled. So far, however, four or five have been the ultimate practical application, and not more than three have stood the commercial test.



Applying the Electric Motor to the Pulp Industry

HEAVY MACHINERY USED IN THE MANUFACTURE OF PULP FOR PAPER MAKING WELL ADAPTED FOR MOTOR DRIVE. BY GORDON FOX

MANUFACTURE of paper, one of our most common and useful materials, involves large consumption of power, the industry probably ranking fourth in this respect. The application of the electric motor in this industry has not merely afforded an effective and convenient driving means, but has made possible many improvements leading to more rapid and more efficient production.

Wood pulp can be prepared either mechanically or chemically. The mechanical process is cheaper and more saving of material, but produces lower grade pulp. It is extensively employed for newspaper print. The chemical processes are used for better grades. Figure 2 gives a flow sheet showing the principal processes and machines involved in wood pulp preparation and paper manufacture, such equipment as conveyors, screens and pumps being omitted. The ground wood or mechanical

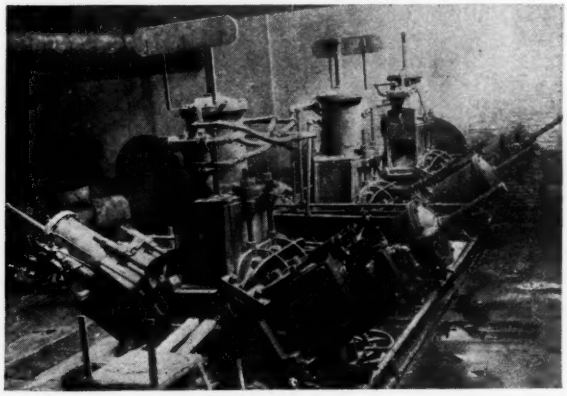


FIG. 1. THREE, THREE-POCKET PULP GRINDERS DRIVEN BY TWO G. E. 1800-HP., 440-V. INDUCTION MOTORS

process of pulp preparation is of most interest from the motor drive viewpoint.

Small logs arriving by water at the sawmill are generally conveyed from the water by a chain conveyor and sawed into 2 ft. or 4 ft. lengths, more commonly by circular gang saws. The blocks of large diameter may then be split in a motor driven splitting machine.

PULP MILL DRIVES

THE ACTUAL preparation of pulp begins in the wood room at the pulp mill. First all bark must be removed as it colors the paper and leaves dirt specks. This may be done by tumbling the blocks in long inclined drums midst a water spray. These drums require a constant running motor of about 75 to 100 hp., depending on size. More commonly barking machines are used. This machine consists of a heavy disk equipped with four knives which cut off the bark as the piece is rotated. The air blast due to rotation of the disk clears the chips into a collector system. Most barkers revolve the wood

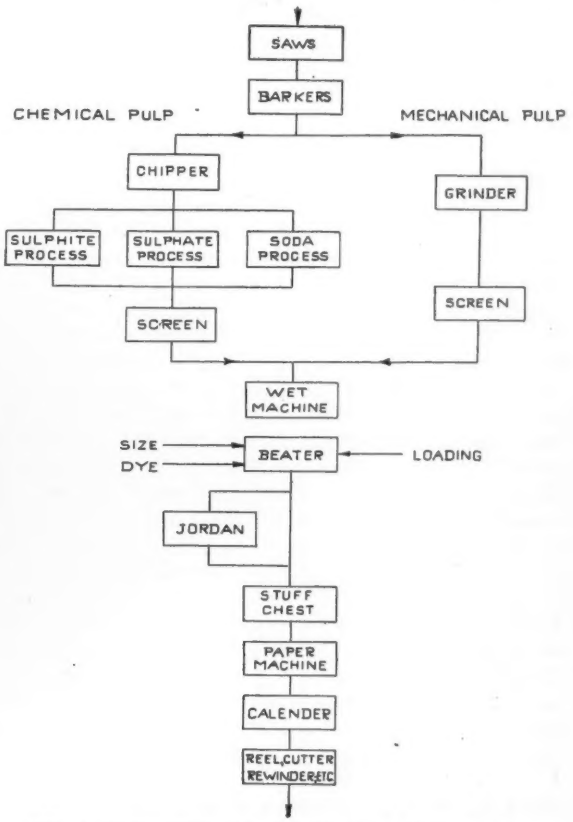


FIG. 2. FLOW SHEET OF PRINCIPAL PROCESSES AND MACHINES IN PULP AND MANUFACTURE

blocks automatically. Barkers are sometimes grouped. More commonly individual motors are belted or direct connected. In the latter case, a flexible coupling should be provided as the machines are subject to vibration due to unbalance of the knives. Squirrel cage induction motors of 10 to 15 hp. are well suited to this application. As the inertia of the machine is high, the starting con-

ditions are a little severe and the indestructible rotor is an advantage.

Chipping machines are used in the preparation of the wood for the chemical processes. These machines slice the wood blocks into short lengths, about 7/8 in. thick, in a direction about 45 deg. across the grain. Sawing is avoided due to the waste and undesirability of sawdust. The chipper is a heavy steel disk or flywheel to one side of the web of which four knives are attached. The blocks are fed endwise into an inclined spout at the side. The knives strike the wood with sufficient force to cut a clean slice. The load demand and also the quality of output depend upon the condition of the knives and also on a snug fit of the bedplate at the base of the spout, to prevent pinching and afford a clean cut. These machines require motors ranging from 75 to 150 hp. capacity, depending on stock handled. The load is of a highly fluctuating and peaked character and the motor should have a high pull-out torque. High inertia must be overcome in starting. Either a wound rotor induction motor or a squirrel cage motor with high resistance rotor may be used to advantage, utilizing the flywheel effect to assist in load equalization. Drive should be by belt, as these machines are subject to jarring. A three-bearing motor is preferable.

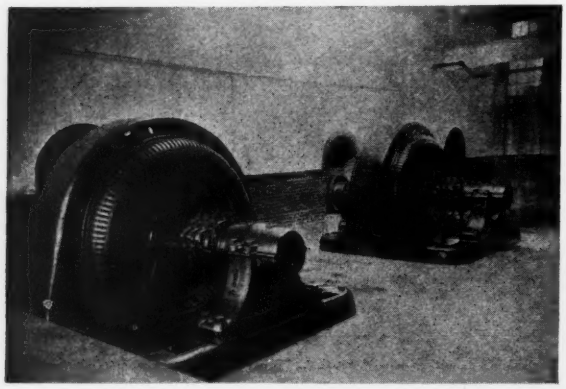


FIG. 3. TWO 1800-HP., 440-V., 25-CYCLE INDUCTION MOTORS DRIVING THREE THREE-POCKET GRINDERS

Pulp grinders, for the preparation of ground wood pulp, are large users of power. These consist of a large grindstone about 54 in. diameter and having usually a 27-in. or 54-in. face for 2-ft. or 4-ft. blocks. The stone is mounted on a horizontal shaft and encased. Three or four compartments are provided into which the barked blocks are introduced with their axes parallel to the shaft. Hydraulic cylinders in the heads of these compartments supply the pressure which holds the blocks against the stone. Water is used to keep the wood from burning and to carry away the ground pulp. If the water is controlled to give a grinding temperature of about 160 deg. F., the grinding is more rapid and coarser pulp is produced than if ground cold.

Hot ground wood is used for news print and cold ground pulp for better grades of paper. Production is also dependent upon the cylinder pressure and the stone speed. The unit pressure on the surface of a block changes as the contact area changes, due to its cylindrical shape. Moreover, frequent reloading of pockets is necessary. Because of these variables and also due to differences in materials and products, opinions differ widely as to proper speeds and pressures for grinding. Therefore the horsepower required on a given machine may differ materially according to method of operation adopted. Speeds range from 215 to 260 r.p.m. Capacities run from 2 to 7 T. in 24 hr. Usual power demand is about 75 to 100 hp. per ton of pulp produced in 24 hr., thus calling for about 200 to 600 hp. per machine.

Pulp grinders are very commonly driven by water power. Motor drive offers some advantage, notably as to continuity of power, speed regulation and increased production. Uniform speed is important as a lower speed decreases production and a higher speed causes an excess of splinters and short fibers. From 1 to 6 grinders are driven by one motor. Where several grinders are group driven, their shafts are connected in series or train. All the grinders may be grouped on one side of the drive or half may be placed on each side. The former arrangement allows the motor to be placed in a separate room away from the dirt and slush and also permits better handling of the wood. The latter arrangement enables half the group to be operated independently by disconnecting a coupling. Direct connected slow speed motors are almost universally employed to drive pulp grinders or groups. Flexible couplings should be introduced between the motor and driven shaft to prevent any weight from the stone being thrown on the motor bearings.

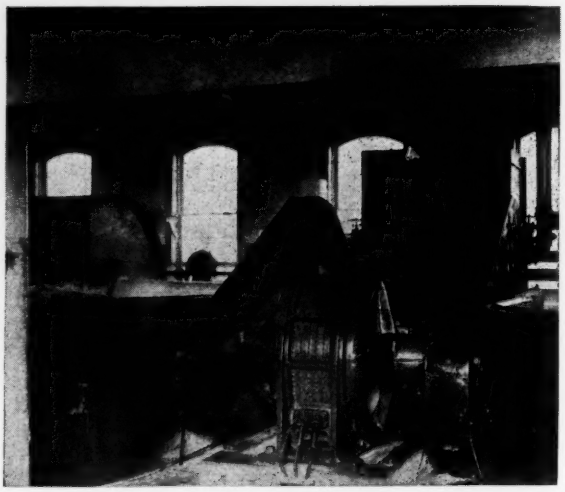


FIG. 4. 150-HP. INDUCTION MOTOR DRIVING TWO BEATERS THROUGH CHAIN BELTS

Starting requirements of pulp grinders of the smaller sizes are not particularly severe. The squirrel cage induction motor may be used unless the large size of motor involved dictates the use of wound rotor motor to minimize starting peaks. Synchronous motors may offer considerable advantage from the viewpoint of power factor, particularly because of the magnitude of the load. Their maintained speed is also a favorable factor. Their use is increasing and is to be recommended. With the heavier stones, starting torques are sometimes rather high due to static friction. To start these equipments with synchronous motors would involve too high current peaks on the power system. Motor generator sets are sometimes used to supply variable

frequency and voltage at starting. The set comprises an adjustable speed direct current motor driving an alternating current generator. The synchronous motor is operated from this generator. As the motor generator set is slowly accelerated and its voltage simultaneously increased, it brings the synchronous unit up to speed with it. The motor is then synchronized and connected to the main power supply system. One motor generator set may be used to start singly a number of synchronous motors.

Mention has been previously made of the fluctuation of load on pulp grinders due to changes of contact surface and loading intervals. In order to maintain maximum production and full load on the motors indicating meters for the operators have been supplied, but with indifferent success because of attention required to adjust hydraulic pressures manually to govern the load. Electrically operated regulators have been perfected which perform this function automatically in response to load changes on the motor.

These are very effective, increasing the production and improving the quality of the pulp. They also prevent both overloading and unloading of the motors and restrict the maximum demand. They relieve the operators and take from them the control of production, which may be an important consideration.

Either ground pulp or chemical pulp is obtained mixed with a large quantity of water. If it is desired to transport the pulp, the excess water is removed in a wet machine. This consists of a cylinder of fine wire mesh revolving partly submerged in a vat of pulp and water. As it revolves, it carries a coating of pulp on the surface while a large amount of water runs through the screen. This coating is transferred to a felt, carried between pressure rolls, and finally wound on a cylinder. When this cylinder has a sufficient number of layers wound on it the entire coating is scraped off and folded. This machine starts light and runs at constant speed and may well be driven by a squirrel cage induction motor.

Paper Mill Drives

Manufacture of paper begins in the beater room and it is in this department that a large proportion of the power in the paper mill proper is consumed. A beater is a large oval tank with a central vertical partition, extending about half the long axis, leaving the ends open and forming a channel for the flow. On one side of the tank, between the midfeather and the wall, is a cylindrical beater roll or drum which is equipped with a large number of bars or dull knives. Directly under this roll is a bedplate also carrying knives skewed at an angle. The drum is revolved, causing the pulp stock to circulate around the tank and pass between the drum and the bedplate. The beater roll may be accurately raised and lowered. Into the beater are fed the pulp stock, coloring matter, fixing solution, size and filler as required. The function of the beater is to cut, or rather to tear and separate the pulp into fibers of desired lengths and to mix the ingredients. The material is treated in batches, the process requiring from a few minutes to several hours according to materials and product desired.

Beaters are constructed in several sizes with corresponding roll speeds ranging from 80 to 160 r.p.m., but of a constant value for any one machine. About half the load of a beater is taken in circulating the water and stock, the other half being taken in beating, due to the friction between the roll, the stock and the bedplate. As the beating of a batch proceeds, the roll is lowered at intervals, increasing somewhat the power demand. As the stuff becomes more homogeneous and the fiber shorter, the fluctuations decrease. The power demand depends upon the roll size and speed, the stock used, the product required and the method of working. A beater working on rag stock requires a much larger motor than if used on wood pulp. Therefore each installation requires individual consideration. Motor capacities range from ¾ to 1¼ hp. per in. roll face and from 35 to 100 hp. per beater.

The starting torque demanded by a beater may be as high as twice full load torque. Wound rotor induction motors are therefore commonly installed. Squirrel cage motors are also used for the smaller units but may be deficient in starting torque and may also be objectionable due to rather sudden shock in starting.

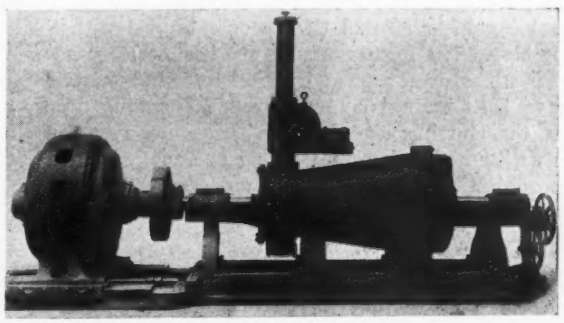


FIG. 5. SQUIRREL CAGE INDUCTION MOTOR DRIVING JORDON. NOTE THE FLEXIBLE COUPLING AND SLIDING BASE

Beaters may be driven singly, in pairs or in groups of four. Both belt and chain drives are in common use. Chain drive affords a compact arrangement and permits the use of a wide ratio and rather high speed motor. The chain should be of liberal proportions because of the fluctuating load and shock. Belt drive is often preferred as relieving the motor more completely of jar and shock. A common arrangement employs a motor with double extended shaft driving two beaters as shown in Fig. 4. This is open to some objection due to the difficulty of maintaining proper belt or chain tension simultaneously on the two drives. Idler pulleys are sometimes used with belt drives. Individual drive may be of advantage in permitting a meter to be used to indicate the load and assist in governing the operation.

The stuff from the beaters may be further refined in a Jordan machine. This consists essentially of a conical cast-iron shell the inside of which is fitted with long, narrow steel bars. Inside of this shell is rotated a conical "plug" or "runner" also carrying bars. The plug can be moved axially to adjust the clearance between the two sets of knives. The knives or bars are skewed to give a shearing cut effect. The stuff is forced through the Jordan from the small end to the large end. The Jordan does the final refining before the stock passes to the paper machine. The extent of this refining differs according to practice followed. The load on the Jordan is affected by the character of the stock, the rate of production, the extent of refining and the

grade of paper made. Some rag and jute stocks take materially more power because of the long fibers and heavy consistency. The position or clearance of the plug has a decided influence on the load. An ammeter installed in the motor circuit will show when the plug needs chipping or renewing and may also assist to indicate the clearance condition. For the reasons above stated, liberal motoring is necessary but the load demand is normally less than maximum. The factors influencing each individual installation must be considered in selecting motor size. Motors from 75 hp. to 300 hp. are used for different size machines and various conditions.

Jordans rotate at constant speed from 350 to 400 r.p.m., depending upon size and service. These speeds are well suited for direct connection of individual motors and this is the usual method of drive. Aside from compact and efficient arrangement, direct drive minimizes bearing wear and thus assists in maintaining the plug in a central position. In order to permit movement of the plug, a telescopic coupling is provided or a flexible coupling installed and the motor equipped with a sliding base. The former arrangement is more common.

Both squirrel cage and wound rotor induction motors have been extensively employed for driving Jordans. As the starting load is light the squirrel cage motor is well suited unless its starting current inrush is open to objection. The synchronous motor is entirely adapted to Jordan drive and is particularly desirable because of the fact that it may be fractionally loaded much of the time. This type of drive has not seen extensive use, but is gaining in favor.

We have now considered the various mechanical processes involved in the preparation of pulp and paper stuff. It will have been noted that relatively large powers are involved in many of the processes, that constant speed drives are required and that alternating current motors are therefore recommended and commonly employed. Electric power is most easily available in this form and this type of motor is in general more rugged. The conditions around pulp and paper preparation mills are quite severe. Loads are more or less peaked. Machines are subject to some jar and vibration. Service is continuous and shut downs may seriously cripple production. Reliability is therefore a paramount consideration. The motors are exposed to moisture and subject to temperature changes. The windings should therefore be specially treated. Starting conditions are liable to be unfavorable, at least on occasions due to cold. The starting peaks and fluctuating loads render desirable the use of inverse time element overload protection. In general, simple manual control, as rugged as possible and well protected, should be employed.

In another article the author will take up the application of the electric motor to the actual manufacture of paper.

Identifying Untagged Induction Motor Leads

VOLTMETER AND LAMP OR BUZZER USED IN TRACING WINDING AND PROPERLY CONNECTING LEADS TO LINE. BY L. G. TUBBS

A THREE-PHASE motor with three leads brought out should be connected to the line in any convenient way and then, if it rotates in the wrong direction, any two leads should be interchanged. A two-phase motor with four leads may be lighted out to determine which leads belong to one phase. These two leads are then connected to one phase of the line and the other two leads to the other phase. Then if the motor rotates in the wrong direction the two leads of either phase should be interchanged. The real problem comes with the double voltage and consequent pole motors which have more leads and circuits.

DOUBLE VOLTAGE MOTORS, THREE-PHASE STAR CONNECTION

THIS TYPE of motor will have nine leads and four separate circuits as shown in Fig. 1. Three circuits have two leads each and one has three leads. The circuits should be tested out with a lamp or buzzer and the three leads on a common circuit forming the internal star should be permanently tagged T_4, T_5 and T_6 in any order. The other leads should be temporarily tagged T_1, T_7 for one circuit, T_2, T_8 on the second circuit and T_3, T_9 on the third circuit. It will be assumed that in all cases of double voltage the motor is wound to operate on 220-440 v., as this is the most common voltage range. For any other voltages, all the subsequent test voltages should be changed in proportion to the motor rating.

The motor may now be started on 220 v., leads T_4, T_5 and T_6 being connected to the source of power and all other leads left disconnected. If the motor is too large to be started by connecting it directly to the line, the starting voltage should be reduced as in the regular operation of the motor. With the motor running light,

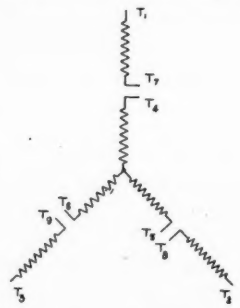


FIG. 1. THREE-PHASE, TWO-VOLTAGE WINDING—SINGLE-SPEED, SERIES AND PARALLEL-STAR CONNECTIONS

the voltage across each of the three open circuits should be measured. This voltage should be slightly under 127 v. and should be the same on all three circuits. With the motor still running, connect T_4 to T_7 and measure the voltage across leads T_1 and T_5, also T_1 and T_6. If these voltages are both of the same value and equal about 335 v., tags T_1 and T_7 should be marked permanently. If the two voltages are of the same value and equal about 127 v., interchange T_1 and T_7. If the voltages between T_1, T_5 and T_1, T_6 are unequal, then disconnect T_7 from T_4 and connect T_7 to T_5, measuring the voltages between T_1, T_4 and T_1, T_6.

Changes and measurements should be made in this way until a position is found at which both voltages are

equal and of a value of about 335 v. as described above. After this position is found, the markings on the terminals of the circuits tested are made permanent and to agree with the position in which the correct voltage balance was found, according to schematic diagram in Fig. 1. The same procedure should be followed out for each of the remaining two circuits, permanent tags of proper markings being placed on each as its position is found.

When all the leads have been permanently tagged, with the motor still running light, and leads T_4, T_5, T_6 being used as terminals, leads T_7, T_8, T_9 may be connected together and the voltage read between leads T_1, T_2, T_3. The voltage thus read should equal approximately 220 v. For a further check, the motor should be shut down and reconnected, using leads T_1, T_2, T_3 as terminals, with T_7, T_8 and T_9 connected together and leads T_4, T_5 and T_6 disconnected. Care should be taken to connect the line to T_1 that was on T_4, the one to T_2 that was on T_5 and the one to T_3 that was on T_6. The direction of rotation should be the same as with the previous connection. The motor is now ready to operate on 220 v. by connecting T_7, T_8 and T_9 together and using T_1, T_4 as one lead, T_2, T_5 another and T_3, T_6 a third. By connecting T_7 to T_4, T_8 to T_5 and T_9 to T_6 and using T_1, T_2, T_3 as leads, the motor should operate on 440 v.

Three-Phase Delta Connection

This type of motor will also have nine leads but only three separate circuits, three leads being

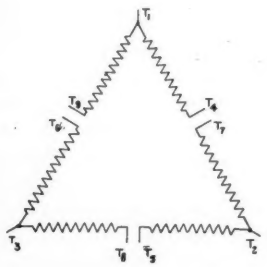


FIG. 2. THREE-PHASE, TWO-VOLTAGE WINDING—SINGLE-SPEED, SERIES AND PARALLEL-DELTA CONNECTIONS

connected to each circuit. In this case it is necessary to have some facilities for measuring resistance, only comparative values and not actual values being required. This can be obtained with a Wheatstone bridge, if one is available, or comparative results can be obtained by taking the voltage drop over the various parts of the circuit with a millivolt meter, using a constant value of direct current in the windings which should not exceed the current rating of the motor. Reference to Fig. 2 shows that it is necessary to find leads T_1, T_2 and T_3. This can be done by an approximate measurement of resistance, since the resistance from T_4 to T_9 is twice that from T_4 to T_1, whence T_1 is located. T_2 and T_3 are similarly located by corresponding measurements in the other circuits. These leads should be permanently marked. The remaining leads in the circuit containing T_1 should be temporarily marked T_4 and T_9; those in the same circuit with T_2 should be marked T_5 and T_7; and those in the same circuit with T_3 should be marked T_8 and T_6 in any order.

After leads T_1, T_2 and T_3 have been located, the motor should be started and run on 220 v., using T_1, T_4 and T_9 as leads and leaving all other terminals disconnected. As all the leads are alive, precautions should be observed to prevent short-circuits between leads of the same group. T_4, T_7 should then be connected together and the voltage read between T_1 and T_2. If this voltage equals approximately 440 v., the marking is correct. If this voltage is approximately 380 v., interchange T_5 and T_7 or T_4 and T_9 and measure the voltage again. If it is approximately 220 v., interchange both T_5, T_7 and T_4, T_9. When this voltage equals approximately 440 v., mark T_4, T_9, T_7 and T_5 permanently, taking care that leads are marked T_4 and T_7,

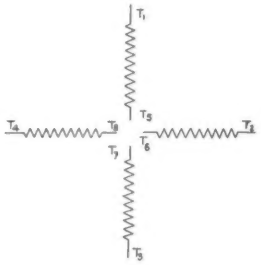


FIG. 3. TWO-PHASE, TWO-VOLTAGE WINDING—SINGLE-SPEED, SERIES AND PARALLEL CONNECTIONS

which when connected together gives 440 v. between T_1 and T_2. A similar procedure should then be followed, connecting T_6 to T_9 and measuring the voltage between T_1 and T_3. When the markings are all correct, the voltages between T_1, T_2 and T_3 should equal approximately 440 v.

After all the leads have been tested out as above and permanently marked, as a check the motor should be shut down and reconnected, using T_2, T_5 and T_7, as leads. Care should be taken that T_7 is attached to the line previously connected to T_9, T_2 attached to the line previously connected to T_1 and T_5 attached to the line previously connected to T_4. When the motor is again started, the direction of rotation should be in the same direction as with the previous connection. If the direction of rotation is correct, the motor should again be reconnected using T_3, T_6, T_8 as leads and connecting the line from T_5 to T_6, the line from T_2 to T_3 and the line from T_7 to T_8. When the motor is again started, the direction of rotation should be in the same direction as with the previous connections. When the above tests have been completed, the motor is ready to be connected permanently. If it is desired to run the motor on 220 v., connect T_6, T_1 and T_7 together, and use as one lead, T_4, T_2 and T_8 as a second lead and T_3, T_9 and T_5 as a third lead. If it is desired to run the motor on 440 v., connect T_4 to T_7, T_5 to T_8, and T_6 to T_9, using T_1, T_2 and T_3 as leads.

Two-Phase, Double-Voltage Motor

This can always be distinguished by the fact that eight leads are brought out. Trace out the circuits by a lamp or buzzer as in the previous case. There should be four separate circuits with two leads to a circuit. Temporarily tag the leads on the first circuit T_1, T_5; those on the second circuit T_2, T_6; those on the third circuit T_3, T_7; and those on the fourth circuit T_4, T_8.

Start the motor and run it single phase on 220 v., using any pair of leads from a single circuit. In order to do this it will be necessary to bring the motor up to speed by externally applied power. This is pref-

erably done by belting it to another motor; however, any available means of giving the motor a slight start is satisfactory, as it will come up to speed single phase if given a sufficient start. As in the previous case, short-circuits between leads of the same group should be avoided. Then connect T_7 to T_5 and measure the voltage from T_1 to T_3. If the voltage equals 440 v., mark T_1, T_5, T_3 and T_7 permanently. If this voltage is zero, interchange either pair of leads. If the voltage measured equals approximately 310, disconnect T_7 and try leads from another circuit until one is found which will give 440 v. from T_1 to the lead on the other end of the circuit. When such a circuit is found, mark the leads permanently T_1, T_5, T_7 and T_3, being careful that leads marked T_5 and T_7 are those which when connected give 440 v. between T_1 and T_3. This procedure should then be followed with the other four leads making final markings as shown in Fig. 3. When all the leads have been marked as above, the motor may be connected for 440 v. operation by connecting T_5 to T_7, T_6 to T_8 and using T_1, T_3 as leads for one phase and T_2, T_4 as leads for the second phase. For operation on 220 v., connect T_1 to T_7, T_2 to T_8, T_3 to T_5 and T_4 to T_6. Use T_2, T_8 and T_4, T_6 as leads on one phase and T_1, T_7 and T_3, T_5 as leads on the second phase.

Two-Speed, Consequent-Pole Motors

An induction motor using the consequent pole principle to obtain two speeds with a single winding requires that six leads be brought out. In this case all leads are

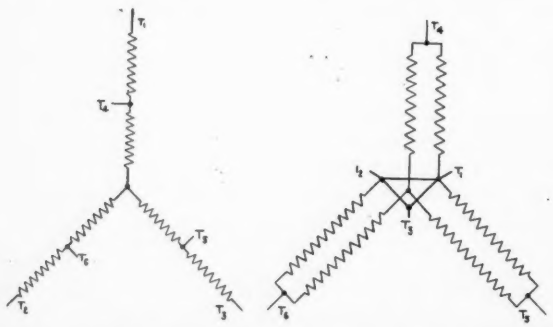


FIG. 4. THREE-PHASE, TWO-SPEED WINDING—SERIES-STAR AND PARALLEL-STAR CONNECTIONS

interconnected, so that it is not necessary to test for separate circuits. In the following discussion it will be assumed that the motor is wound to run on 220 v. If it is wound for any other voltage, the test voltages given should be changed in proportion to the change in rating.

In the Star-Connected Motor the resistance between three of the leads will be double that between the remaining three leads. The three leads having the highest resistance between them should be located and their terminals permanently marked T_1, T_2 and T_3. As a check, the resistance between the terminals so marked should be equal and should be double the resistance obtained between any pair of the remaining terminals, and these latter should also be equal. The motor should now be started and run on normal voltage, using T_1, T_2 and T_3 as leads with the remaining leads disconnected. The motor should run at its normal slow speed. With the motor running, the voltage between T_1 and the unmarked leads should be determined. The lead giving approximately 63 v. to T_1 should be marked T_4; the lead giving 63 v. to T_2 should be marked T_6 and the remaining lead marked T_5. For running at slow speed T_1, T_2 and T_3 should be used as leads and T_4, T_5 and T_6 left disconnected, giving a series star connection as shown at the top in Fig. 4. For running the motor at high speed, T_4, T_5 and T_6 should be used as leads and T_1, T_2 and T_3 connected together, as shown in the diagram to the right in Fig. 4. This gives a parallel star connection with alternate poles reversed, which is the necessary condition for consequent pole operation.

The delta-connected motor may be distinguished from the star-connected by measuring the resistances. The lowest value of resistance obtainable between any two leads should be found, and if the motor is delta con-

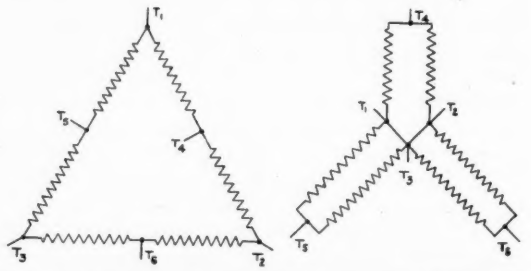


FIG. 5. THREE-PHASE, TWO-SPEED WINDING—SERIES-DELTA AND PARALLEL-STAR CONNECTIONS

nected it will be possible to go through all the leads, measuring the lowest value of resistance from lead to lead and ending up at the lead at which the start was made. Starting with the first pair of leads which give the lowest resistance between terminals, mark them temporarily T_1 and T_4. The lead should then be found which will give a resistance to T_4 equal that between T_4 and T_1. When this lead is found, it should be marked T_2. The lead should then be found which will give the same resistance to T_2 as that between T_2 and T_4 and this lead should be marked T_6. This procedure should be followed until all the leads have been used. They should be marked from the beginning and in the order in which they are found T_1, T_4, T_2, T_6, T_3 and T_5. When all leads have been marked as above, the motor should be started and run single phase with 110 v., or one-half motor voltage impressed on two leads marked by adjacent numbers in the above order. The voltage should then be measured between T_1 and T_2, between T_2 and T_3 and between T_1 and T_3. This should equal 220 v. If the voltage from T_1 to T_2 equals only 110 v. then remark all the leads changing T_4 to T_1, T_2 to T_4, T_6 to T_2, T_3 to T_6, T_5 to T_3 and T_1 to T_5.

Start up again and with 110 v. single-phase impressed on T_1 and T_4 check the voltage from T_1 to T_2, from T_2 to T_3 and from T_3 to T_1 which should equal 220 v. To run the motor at slow speed, use T_1, T_2 and T_3 as leads with T_4, T_5 and T_6 disconnected, giving a series delta connection as shown at the left in Fig. 5. To run at high speed use T_4, T_5 and T_6 as leads with T_1, T_2 and T_3 connected together, giving a parallel star connection with alternate poles reversed, as shown in the right hand diagram in Fig. 5.—The Electric Journal.

Lubricating the Steam Engine Cylinder

DEVELOPMENT OF MODERN MEANS AND POINTERS ON THE CARE OF HYDROSTATIC LUBRICATORS AND FORCED FEED PUMPS. BY R. A. CULTRA

PROPER lubrication of the interior of the cylinder has confronted the engineer ever since the invention of the steam engine. During the first years of its development, steam pressures and temperatures were low and although the only lubricants available at that time were animal fats, mostly mutton tallow, these were used with a fair degree of success. These fats were used on nearly all types of machinery. On bearings some fish oil was usually mixed with the fats.

Necessity for introducing oil into steam cylinder brought about the development of a suitable device for accomplishing this. The first device of this kind consisted of a plain cylindrical cup which was screwed into the top of the steam chest or any suitable place in the steam line close to the cylinder. It had a valve, V, Fig. 1, which could be closed to shut off the steam from the cylinder and at the same time prevented oil from leaving the cup. In order to operate this valve, it was necessary first to close the valve V, and remove the plug P, then fill the lubricator with tallow or grease and replace the plug P. Upon opening the valve V, the oil or grease would pass from the lubricator into the cylinder or steam line, at a rate dependent upon the amount of opening of the valve. If upon removing the plug in the top of this lubricator preparatory to filling, it was found to be filled with water, it was necessary, first, to empty the device by slightly opening the valve V. Although unsatisfactory in many ways, this device was for a long time the only one on the market for this purpose. It fed the lubricant all at once, or in cold weather, not at all. When empty the cylinder received no oil and the piston and valves ran dry until filled again, nevertheless it was the forerunner of present types of lubricators.

Figure 2 is one of the first types of sight feed lubricators, made for feed regulation at the valve. G is the sight glass, set over a small chamber which accumulates sufficient water and the drop of oil passes from the drip hole at the bottom by the glass G, passes out, discharges into the steam pipe at B. K is a stop valve which shuts off the steam and F the feed valve to shut off the discharge side when the drain D can be opened to let out the water. The plug P could then be removed and the cup A filled with oil. Replacing the plug P, opening the valve K and starting the feed at F, puts the device in operation.

This lubricator had many faults. Steam pressures and temperatures were going higher and at this time good cylinder oil could be had that would lubricate up to 85 or 100 lb. For this pressure the oil would require heating before filling the lubricator, and often the lubricator would get hot and the oil foam up through the sight glass chamber, when the engine was stopped the oil cooled and this little chamber would be filled with thick cylinder oil, with no way to remove it except to take off the cap and sight glass.

One great trouble was the lubricator becoming empty and steam getting into the chamber which would expel the water and after the lubricator was filled with oil, no water could be condensed in the sight feed chamber and the chamber would fill with oil. It would feed all right while hot but the rate of feed could only be guessed at. When it became empty the water expelled the oil and the sight feed chamber was again filled with water. If it was shut off and refilled at this point before it became hot, it would work as usual. But this condition showed the need of a sight glass besides the feed glass. The amount of oil in the lubricator could be seen at any time and refilling before completely empty would prevent clogging of the sight feed glass, also save time and insure better lubrication to the cylinder.

Another type of lubricator showing much improvement is illustrated in Fig. 3. It is of the gravity

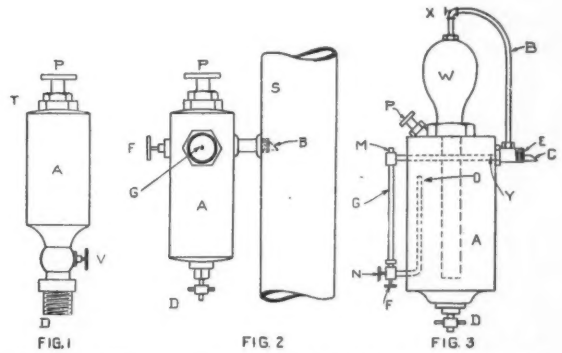


FIG. 1. FIRST TYPE OF LUBRICATOR USED ON STEAM CYLINDERS

FIG. 2. EARLY TYPES OF SIGHT FEED LUBRICATOR

FIG. 3. CONDENSER, SIGHT FEED AND GAGE GLASS WERE NOTEWORTHY IMPROVEMENTS IN LUBRICATOR DEVELOPMENT

pressure feed type and is still in use in some plants. A is the case; B, the steam pipe connection; X, a stop valve, and W, the water storage compartment. In operation the chamber A is filled at P with cylinder oil and the valve X is then opened, then the valve at Y. The water settles to the bottom of the chamber the oil floating on it at the top. Opening the sight feed valve F the oil passes into the top of the internal pipe line at O, down through the feed valve F and the drops go up through the glass G, discharging into the steam pipe at C. The steam enters at E on the outside of the pipe C and condenses in the chamber W. On some makes of lubricators there is a valve between the water chamber W and the oil chamber A. With such a valve closed the chamber W is left full of water while draining the water out at D for filling.

This lubricator had a gage glass on the left hand side, not visible, besides the sight feed glass, which showed the height of oil in the chamber A, so the chamber could be refilled before it became completely empty or hot. When the lubricator becomes empty and hot, the water in the sight feed glass will become hot and particles of oil stick to the sides of the glass until it becomes so thickly coated as to make the drops invisible or the oil to stick to the side of the glass and run up one side in a steady stream, making it impossible

to tell at what rate the oil is feeding. In such a case it is necessary to clean out the glass by removing the plug M at the top. Take a small stick, wind a little waste on one end and use as a swab to clean out the glass.

If it is necessary to empty the glass as in cold weather, opening the little pet cock N at the bottom will drain the glass; but in this case it requires a long time for sufficient steam to condense to fill the glass with water, so when the lubricator is hot, it is better to remove the plug M at the top and put in fresh water. In putting in a new glass it is always put down through the top connection after removing the plug.

Some engineers use glycerine to fill the sight feed glass, as it keeps the drops of more regular size; but if the lubricator should get empty, this glycerine is sent over into the engine and the glass will have glycerine and water in it. Also with glycerine in the glass it is not possible to blow out the glass when even slightly dirty without the waste of the glycerine. A very good practice is to wash the glass out and fill it with water. Packing small pieces of soap around the feed nozzle will

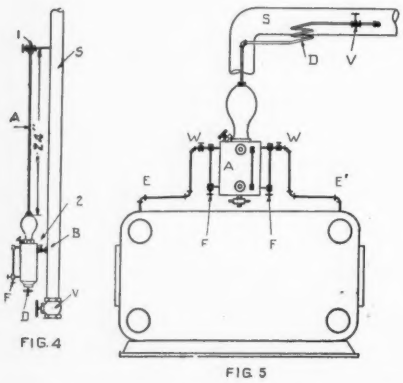


FIG. 4 FIG. 5 FIG. 6

FIG. 4. LONG CONDENSING PIPE ADDED TO RELIABILITY OF LUBRICATOR

FIG. 5. LUBRICATOR WITH COIL CONDENSER AND DOUBLE FEED

FIG. 6. LUBRICATOR CONNECTION ABOVE AND BELOW THE THROTTLE VALVE

keep the water a milky color, but the drops of oil can be seen easily and they will not stick to the side of the glass while the soap lasts. When the soap is gone, which will be some length of time, more can be put in; this is an inexpensive liquid and requires very little time.

In washing out the sight glass, never use a piece of wire to swab it out with, especially copper wire, it seems to have a crystallizing effect on the glass. The glasses will always break soon after, often a few minutes after. A stick of wood is always better. This lubricator, like its predecessors, had its advantages. It would get hot and could not be used until cooled off, or if too cold, it would be some time before it could be thoroughly warmed up to feed properly and it could be used only in fairly cool but not cold places and in hot places not at all.

In Fig. 4 is seen the next type of lubricator to appear. It is no different in principle, the only change is that condenser pipe A is connected to the steam pipe about 2 ft. above the lubricator instead of being connected as at B in Fig. 3. The object of the connection in Fig. 4 was to give better condensing area, and utilize the weight of the water in the pipe in addition to overcome the pressure at the discharge point B in the steam pipes and help to force the oil out through the sight feed valve F. In this way a lubricator was developed which could be used in either hot or cold places and be relied on to feed.

In making the connection of the condenser pipe there is not always sufficient room to extend the condenser pipe 24 in. above the lubricator which is generally on top or above the cylinder, without hitting the low ceiling. Often the lubricator is connected above the throttle valve, and in case of pumps using automatic regulator valves, it is necessary that the discharge or some of the discharged cylinder oil should pass through this automatic regulator valve or it will become dry and stick. Also the oil discharged above the throttle valve keeps the thread on the stem well lubricated and it will work easier and the packing last longer.

To get sufficient condenser pipe above the lubricator and have enough weight of condensate, it is often necessary to put a coil of ½-in. pipe above the lubricator and connect it to the steam main at some distance away as in Fig. 5. S is the steam main; V, a stop valve, and D, a coil of ¾-in. pipe reduced to ⅜-in. to connect to the lubricator A. This lubricator is made to feed two ways at the same time.

As steam pressures increase so does the temperature of the steam, hence the cylinder oils used in the past are little better than machine oil today. As this change was taking place, some plants kept track of the effect of their lubrication on the valves. The oil companies were desirous that their oils should succeed. The steam and exhaust valves were too dry and it became the theory that the oil was not being distributed evenly throughout the steam chest and cylinder. So this plant installed the lubricator to feed the oil directly onto the steam valves as shown at E, E′. F, F are the sight feed regulating valves and W, W stop valves.

This system developed the fact that the lubricating oil for cylinders did not possess sufficient lubrication at high temperature to keep the valves from getting dry and the oil companies produced a better grade to meet the condition.

When this lubricator was first installed, it gave trouble from heating, as the condenser pipe was a short straight connection to the steam pipe, and did not furnish sufficient condensate until the coil of ¾-in. pipe was made and put in. The steam chest was on top of the cylinder on this engine, hence there was less room for the steam condenser pipe and the indicator attachment prevented the lubricator from being placed at the side of the cylinder. In Fig. 6 is another type of engine which has the steam chest on the side of the cylinder and the covers cannot be removed if a bracket is used to suspend the lubricator, so it too is placed on top of the cylinder, and the connections, as in Fig. 5, are above and below the throttle valve.

While this form of connection robs the throttle valve of all lubrication, it is not a very serious matter; but in shutting down the engine, it is necessary to close both valve in connections to steam pipe as well as the sight feed valve because the discharge below the throttle valve would allow all the oil to be fed into the cylinder

and empty the lubricator. It would get hot and if the gage glass or sight feed glass did not break, there would not be any oil in the lubricator to start with in the morning. When this form of connection is used, the gage glass may break during the night if the steam is not shut off, and where the discharge is above the throttle valve the sight feed glass may break as well and leave the lubricator in bad condition.

With lubricators having several sight feed discharge pipes, it is possible to lubricate a tandem compound engine, discharging the oil directly on the separate steam valves of each cylinder and also above the throttle valve all from the one lubricator, or many more cylinders of a vertical cross-compound engine can be supplied with cylinder oil from the same large lubricator. In such cases the condenser pipe is large and long to furnish ample supply of condensate and a drain pipe can be connected to the drain valve to take away the water when filling. The amount of water is generally one drop for each drop of oil which passes from the lubricator.

In some plants where single discharge lubricators of one quart or less capacity are used, the engineers prefer to regulate the feed by regulating the amount of water which enters the oil chamber. I have found this method fairly satisfactory, but it requires the greatest skill to operate it. The feed valve is left almost wide open and only a drop of water allowed to enter the oil chamber for each drop of oil discharged.

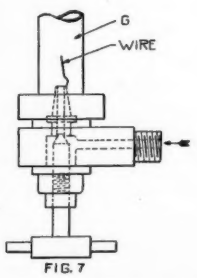


FIG. 7

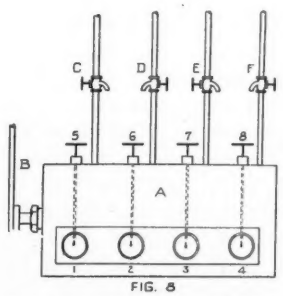


FIG. 8

FIG. 7. WIRE GUIDES DROP TO CENTER OF GLASS
FIG. 8. FORCED SIGHT FEED GANG TYPE LUBRICATOR

When the oil cannot be prevented from going up the side of the glass any other way a short piece of fine wire can be attached to the feed nozzle, Fig. 7, which will guide the oil up through the center of the glass, G.

With the advent of superheated steam and pressures up to 250 lb. and more, it was found that the lubricating oils were still too thin under such high temperatures properly to lubricate the engine valves and cylinder. One engine had the valves badly cut on this account until an oil company installed a lubricator, using a specially made grease of some graphite content. This grease had to be melted with the steam and on account of the graphite content it could not be fed into the cylinder in the usual manner. It was atomized and blown into the steam pipe with a sort of syphon arrangement on the discharge side. This lubricant gave perfect satisfaction in this case.

Forced feeding of cylinder oil has become necessary as the density in some cases and the distance the discharge is carried makes the gravity feeding system almost impossible or at least not desirable. It is simply a small single acting pump operated by a ratchet lever or belt which is connected to any convenient part of the valve gear to get motion and power. Figure 8 shows such a forced feed lubricator made in gang type of several separate pump plungers operated by the same ratchet lever B. A is the oil chamber and 1, 2, 3, 4 are the sight feed glasses showing the amount of oil which drops into the suction chamber of the pumps; 5, 6, 7, 8 are the feed valves for regulating the drop. C, D, E, and F are 3-way stop valves which can be opened to see how fast the oil is being pumped or if the several pumps are working. The pump plungers are supplied with ball suction and discharge valves and occasionally one gets caught up and that prevents it from supplying the oil to the cylinders.

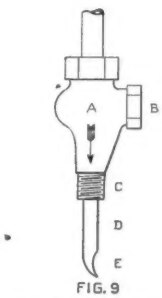


FIG. 9

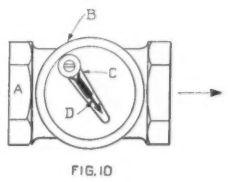


FIG. 10

FIG. 9. TERMINAL CHECK VALVE FOR OIL PIPING
FIG. 10. FLOW INDICATOR FOR OIL IN PIPES

The oil pump is convenient for a large duplex tandem compound pump where several cylinders are to be supplied with oil. It is commonly used on gas engines having many vertical cylinders close together. Like all pumps pumping against high pressure, it is best to have a terminal check valve at the end of the discharge pipe. Figure 9 shows such a check valve with the spray tube D attached. A is the valve body. C is the threaded part which holds it to the steam pipe. The oil runs out on the point E and the steam passing it sprays it into the cylinder. B is the bonnet which can be removed to examine the valve.

With these lubricators it is a good policy to put a little kerosene oil in the suction chamber at regular intervals and pump it through. The kerosene will loosen any thick substances which accumulate in the check valves and prevent the discs from seating and thus keep the pump in working order.

In Fig. 10 is a device called a flow indicator. A is the casing, B is the sight glass and D the arrow on the hinged disc. The oil passing the disc moves it in accordance with the velocity of the oil. The arrow indicates the amount of movement. It is used on steam turbines and can be used on any liquid carrying pipes to indicate the flow of the liquid.

AT THE Pittsburgh, Pa., experiment station of the Bureau of Mines, tests will be made to determine the pressure required to force air at various rates through various thicknesses of nine sizes of anthracite. The information is to be used in estimating the relative draft required to burn these sizes. C. E. Augustine, assistant engineer, has been assigned to the work.

What Is a Heat Balance and How Is It Calculated?

J. R. DARNELL POINTS TO INACCURACIES OF METHOD OF CALCULATING HEAT BALANCE DESCRIBED BY A. W. BINNS, WHOSE REPLY GIVES AUTHORITIES FOR FORMULAS AND CONSTANTS

AS AN engineer, vitally interested not only in the advancement of the science of combustion but in all boiler room problems, the writer wishes to take emphatic exception to a number of statements made in an article by A. W. Binns, appearing in Aug. 15, 1922, number, pages 795—800. This article is called "Simplifying the Heat Balance."

By a curious coincidence, an article which the writer submitted almost identically on the same problem appears in the same issue, pages 821—22. The fallacy of attempting to determine efficiency by flue gas temperature alone was therein discussed. The items necessary to obtain a real heat balance were also touched upon. Mr. Binns not only makes calculations more complicated than necessary, but makes statements which are open to serious question. For instance, he says:

"The percentage of combustible in any coal is equal to the B.t.u. value of the coal divided by the B.t.u. value of carbon. In the case of hard coal, this is equal to B.t.u. of the coal divided by 14,544."

Now, what is meant by combustible? Does it mean ultimate carbon or does it mean the sum of the volatile matter and fixed carbon? It is presumed that ultimate carbon is meant and it also is presumed that the calculation is based on a moisture free basis since 14,544 B.t.u. is the heat value of pure carbon which is naturally free from moisture. Reasoning on this basis, let us study some representative analyses of hard coal as shown by Bureau of Mines analyses.

Kind of Coal	Analysis as Rec'd.		Moisture Free	
	Carbon	B.t.u.	Carbon	B.t.u.
Penn-Barnesboro....	80.53	14,177	82.9	14,596
W. Va. MacDonald..	84.11	14,760	86.9	15,251
W. Va. Big Four....	85.00	14,636	87.0	14,981

Now, according to Mr. Binns, the B.t.u. values of the coal divided by 14,544 should equal the per cent of carbon in the coal. Dividing,

$$\frac{14{,}596}{14{,}544} = 100.4 \text{ per cent}, \quad \frac{15{,}251}{14{,}544} = 104.9 \text{ per cent},$$

$$\frac{14{,}981}{14{,}544} = 103 \text{ per cent}$$

Do these results appear reasonable or possible?

Further on is another radical statement:

"The average per cent of CO_2 can only be obtained by gas analysis. A recording CO_2 meter is, perhaps, the best. A hand Orsat with just the CO_2 solution may be given to the shift foreman, who may be instructed to take samples at a certain time. This method, however, is unsatisfactory for a number of reasons."

Whoever heard of attempting to get really accurate results with a CO_2 recorder? Almost everyone who has had any real experience with these machines knows their failings. They need constant attention and adjusting. By what means are they adjusted if not by the use of an Orsat? Again, even assuming a CO_2 recorder was correct, there is no means of obtaining the oxygen content of flue gas which is also necessary in obtaining heat losses.

A chart is shown with per cent CO_2 plotted against per cent excess air but such charts are only approximate. Accurate results can be shown only when the oxygen value of the flue gas is known.

Taking up Mr. Binns' "Heat Balance" and discussing it item by item, we find his items are given as follows:

1. Heat to steam.
2. Heat loss to auxiliaries.
3. Heat loss to stack.
4. Heat loss to excess air.
5. Heat loss to ash pit.
6. Loss due to hydrogen and moisture in fuel.
7. Loss—Radiation and unaccounted for.
   (CO loss included in item 7).

ITEM 1

IN MOST heat balances this item considers that per cent of the heat in 1 lb. of fuel which is used to evaporate 1 lb. of water from and at 212 deg. F. This is called the efficiency. The feed water is seldom fed to the boiler at 212 deg. F. nor is it evaporated at this temperature. It is necessary to reduce the observed conditions to these standard conditions. Ordinarily it would hardly be necessary to show how this is done but for the benefit of those who are following the discussion the accepted A. S. M. E. method is given herewith.

In running a boiler test of any duration one must start with the water at certain level and end with the same level. Then all the water fed to the boiler during the test will equal the amount evaporated. This is called the apparent evaporation. To get the equivalent evaporation, i. e. the amount of water that would have been evaporated had it been fed in at 212 deg. F. and evaporated at 212 deg. F. atmospheric pressure, it is necessary to multiply the apparent evaporation by a figure slightly more than unity. This is called the factor of evaporation. To obtain this factor the following formula is used:

$$\frac{H - h}{970.4} = F$$

Where H = total heat in steam.
h = heat in feed water.
F = Factor.

Multiplying the equivalent evaporation per lb. of fuel by 970.4 B.t.u. and dividing by the B.t.u. in the coal (usually as received), we get the efficiency. Mr. Binns says:

$$\text{Heat to steam (efficiency)} = \frac{\text{Line output in b.hp.} \times 33{,}900 \text{ B.t.u.}}{\text{Lb. coal per hr.} \times \text{B.t.u. in coal}}$$

Where 33,900 B.t.u. = one B.hp.

If we accept the figure 33,900 (which is somewhat high) we must say that the equation is correct as it stands. But when we consider the inaccuracies of the ordinary type of flow meter, especially where the quality of steam may be variable, considerable error may be

introduced. Further, if no steam flow meter is available and the water must be metered or weighed, how then can this equation give efficiency without preliminary calculations? Wherever the amount of water being evaporated is considered, the temperature of the feed water and the pressure under which it is evaporated must be considered.

ITEM 2.

MR. BINNS says this item is "considered as being the difference in the heat going to the auxiliaries and that which is retained in the feed water heater."

This item is erroneous and unnecessary. If we consider a certain per cent of the heat in the fuel as being absorbed by the water and thereby converting it into steam, what does it matter what becomes of this steam? After the water is vaporized and leaves the boiler we need not give it further attention in so far as the boiler as a heat absorbing agency is concerned.

ITEMS 3 AND 4

THESE items taken separately are as equally in error as the preceding. Mr. Binns intends Item 3 to consider the loss due to the condition of the heating surface, considering only a theoretically correct air supply.

Since a true heat balance considers both the amount of heat which is absorbed and that which is not absorbed, what does it matter whether the heating surfaces are clean or dirty except that what is not absorbed and passes out may be considered as flue gas losses. The heat is either absorbed or it is not. It doesn't hang at any intermediate point.

Item 4 is essentially a duplicate of Item 3, since they are both considered in a heat balance as what is known as the dry gas loss, which is given as follows:

$$\text{Loss in B.t.u.} = W \times 0.24\ (T - t) \text{ where}$$

$$W = \text{lb. dry gas per lb. of fuel} = \frac{4CO_2 + O_2 + 700}{3(CO_2 + CO)} \times C$$

C = per cent carbon in fuel (as received),
0.24 = mean specific heat of flue gases,
T = stack temperature deg. F.,
t = boiler room temperature deg. F.

Supposing now we consider a flue gas analysis with 12 per cent CO_2, 6 per cent O_2, and a difference between room temperature and flue gas temperature of 600 deg. F. The carbon in the coal is 80 per cent and the B.t.u. value 14,000. With these conditions we actually have a dry gas loss of 17.3 per cent. But, using item 3,

Loss = 0.0206 × diff. of stack and air temperature.
Loss = 0.0206 × 600 = 12.4 per cent loss.

Using Item 4

$$\text{Loss} = \frac{.017 \times \text{diff. of temperatures} \times \text{per cent excess air}}{100}$$

With 12 per cent CO_2 according to Mr. Binns' curve we have about 58 per cent excess air.

Loss = .017 × 600 × 58 = 5.9 per cent loss,
12.4 + 5.9 = 18.3 per cent loss,
18.3 − 17.3 = 1.0 per cent difference between Mr. Binns' results and those generally accepted.

Mr. Binns' results, however, are arrived at by using figures which are applicable to only one particular condition, namely, using coal of about 80 per cent carbon and 14,000 B.t.u. Why not have a formula that is applicable to all conditions and all fuels, whether hard or soft coal, wood, oil or gas? Supposing we used coal of 60 per cent carbon and 13,000 B.t.u. The dry gas loss would then by 15.1 per cent and there would then be 3.2 per cent difference between Mr. Binns' results and those arrived at by standard formula.

Going further, we will say that the 1.0 difference shown above is very conservative since his percentage of carbon in coal is obtained by such a method as pointed out before. In order to get a figure approaching 80 per cent carbon by dividing B.t.u. in coal by 14,544, we would have to have coal with only 11,635 B.t.u. But it is absurd to think of coal with 80 per cent carbon and only 11,635 B.t.u. If we were to use these figures in the standard formula we would have a loss of 20.8 per cent instead of 17.3 per cent. Comparing this with the 18.3 per cent arrived at by Mr. Binns' formula, we would have a difference of 2.5 per cent in the other direction.

Mr. Binns' results are also further in error by his use of the excess air chart which gives values too low for the various per cents of CO_2. For example, with 12 per cent CO_2, the actual excess air is 72.5 per cent. This may be obtained by the formula:

$$\text{Per cent excess air} = \frac{1.00}{\dfrac{N_2}{N_2 - 3.782\left(O_2 - \dfrac{CO}{2}\right)}}$$

where N_2, O_2 and CO are the per cents respectively of nitrogen, oxygen and carbon monoxide in the flue gas.

It may also be shown by the standard excess air curve as found in "Helios," page 573.

If 72.5 per cent excess air is taken instead of 58 per cent, item 4 would show a loss of 7.4 per cent. This would increase his total dry gas loss to

12.4 + 7.4 = 19.8 per cent loss.

Comparing this with the 17.3 per cent loss arrived at by the reasonable conditions shown previously, with the standard formula, we have a difference of 2.5 per cent.

But whether, by any juggling of figures, the difference is shown to be either large or small, the whole question involved is that Mr. Binns' formulas are not logical. If they arrive at any definite conclusions, it is only a happen so.

Item 5—This is the only item I found substantially correct.

Item 6—Discussing Item 6—Loss due to hydrogen and moisture in coal—I must again disagree with the author's statement of losses for various fuels which he calls normal. These losses as shown by him are too low. A fair average hydrogen value for anthracite coals is 4.75 per cent. Bituminous coal will run somewhat higher. Two per cent is a very conservative figure for moisture in anthracite. Bituminous coals will have considerably more moisture.

Using the figures 4.75 per cent hydrogen and 2.0 per cent moisture for anthracite, let us consider the loss due to these conditions. The standard formula for calculating these losses is:

Loss in B.t.u. = 9H + per cent moisture [(212 — t) + 970.4 + 0.47 (T — 212)]

where H = per cent hydrogen in fuel,
t = room temp. deg. F.
T = stack temp.

With a stack temperature of 680 deg. F. and a room temperature of 80 deg. F. and using the above values for hydrogen and moisture, the loss for anthracite coal of 14,000 B.t.u. would be 4.0 per cent. For bituminous coal of 12,000 B.t.u., 5.3 per cent hydrogen and 10.0 per cent moisture, the loss would be 6.3 per cent. For fuel oil of 19,000 B.t.u. and 13.0 per cent hydrogen, the loss would be 8.1 per cent.

Item 7—Radiation and convection losses need not be determined by difference, i. e. by subtracting all other losses from 100 per cent. Using Stefan-Bolzman's Law, compensated by a factor for convection losses, we can check very closely.

$$\text{Loss in B.t.u. per sq. ft. per hr.} = F\left\{.1600\left[\left(\frac{T}{1000}\right)^4-\left(\frac{t}{1000}\right)^4\right]\right\}$$

Where

F = convection factor =
2.0 for small closed rooms,
2.5 for larger rooms (boiler rooms) where there is a slight air circulation.
4.0 for out of doors with mild winds,
5.0 for out of doors with strong winds,

T = temperature of radiating surface deg. F. (absolute).

t = Absolute temperature surrounding air.

It is a pretty good policy not to attempt a heat balance unless all the items can be obtained; at least, all but the radiation and convection losses. Where two or three items have to be estimated or are not known at all the heat balance doesn't mean much. There is really no balance. It is better directly to determine the efficiency only and not worry about the losses.

J. R. Darnell.

Reply to Criticism of "Simplifying the Heat Balance"

I am deeply indebted to Mr. Darnell for his close and complete criticism of my work on "Simplifying the Heat Balance," which might more properly have been called "Complicating the Heat Balance" if Mr. Darnell's observations are correct.

I do not propose to dwell at great length on the previous work. I believe it to be substantially correct. As I clearly stated, the work is not original with me. Most of it comes from the publications of the Bailey Meter Co. In the heat balance discussions run by that company in Power Plant Engineering most of the formulas which I developed will be found. Again the same formulas which I used may be found in an article by H. D. Fisher in the September, 1920, issue of Combustion. The Excess Air-CO_2 curve comes from published tests by the University of Illinois and I have also checked it closely myself.

The outgrowth of the system I outlined has been successfully applied to a plant of several thousand horsepower. I know it has been successful.

One statement which I made Mr. Darnell persistently ignores, namely that the work applied only to a specific installation and was not a general treatise. I had not thought it necessary to drill through the absolutely set and conventional formulas presented in every text book. Mr. Darnell concludes by inferring that the usual method is frequently not available and advises us "not to worry about our losses." This is surely a most pernicious and ill-advised doctrine.

Now, replying briefly as possible, point by point:

By combustible in coal is meant, of course, the volatile combustible plus the fixed carbon; that is, the coal as received, less ash, less moisture. In the original manuscript instead of "any coal" I had "'our coal." That, in the type of coal we use, the B.t.u. of the coal divided by the B.t.u. of carbon, equals approximately the per cent combustible in the load is absolutely true.

The statement is made that it is "absurd to think of a coal with only 80 per cent carbon and 11,635 B.t.u. per lb." These very conditions are absolutely representative of all the steam boiler plants using steam sizes of hard coal which I know of. That the per cent combustible is approximately equal to the B.t.u. of the coal divided by the B.t.u. of carbon is also borne out by some 500 B.t.u. determinations by a Parr chemical calorimeter and proximate analysis on the same samples, which were made over the last 3 yr. I will leave it to the readers of Power Plant Engineering to decide whether or not 14,000 and 15,000 B.t.u. coals are fair coals to use as typical. In these cases the hydrogen and high volatile combustible matter do throw the calculation out some, although not nearly as badly as Mr. Darnell represents it, as he has not used the volatile matter plus the fixed carbon as the total combustible of the coal.

I frankly disagree with Mr. Darnell that a recording CO_2 meter cannot be accurate; that is, as accurate as a hand Orsat, in the hands of a shift engineer. Bear in mind that we are dealing with continuous operating records and not test records. With the hand Orsat the human factor enters. The engineer forgets, he is tied up elsewhere or the temptation to boost his showing proves too strong for him. I would again insist that I have written and thought as an operator who runs his plant 365 days out of the year and not as the test engineer who makes one test, spends two weeks figuring it up, turns it in to the general manager and then departs.

The boiler room is no place for "Vernier Caliper" work. Nobody will ever know the exact heat balance of any plant. Refer to the introduction of Dr. Fernald's book, "Engineering of Power Plants." Here a great authority sends his graduates out into the field with the advice that "In practice, accuracy may mean within 20 per cent and not the seventh place to the right of the decimal."

By this Dr. Fernald by no means advises inaccuracy but he knows power plants and is under no delusions.

For instance, out of 1,000,000 lb. of coal only one ounce or less is finally used in determining the calorific value. With the most careful sampling, the determination is only a good guess. Anybody who has ever made a CO_2 traverse of the last pass of a boiler setting knows how very difficult it is to get a representative sample. Even in the main stream the CO_2 will vary 2 or 3 per cent and the other gases likewise. Also it is a virtual

impossibility to get a true ash sample. Every known meter, however carefully checked, will run out more or less and frequently more. It was largely in view of these facts that Dr. Fernald says what he does.

Mr. Darnell states that the CO_2 excess air curve is approximately correct, which is all I claimed for it.

Item 1 Mr. Darnell proves is correct. Again, it is a specific installation, and it is practical operation and not laboratory tests that we are dealing with. The constant used takes care of our average factor of evaporation.

In Item 2 we are dealing with "Over-all plant efficiency" and not "Boiler efficiency."

Items 3 and 4 were taken from Mr. Bailey's heat balance discussion in Power Plant Engineering, March 1, 1921 and April 1, 1921. Mr. Bailey is admittedly one of the foremost combustion engineers of America and I have implicit faith in the correctness of his work. A careful study of Mr. Darnell's criticism on these two items reveals nothing needing comment. His work is, of course, correct; it is simply the old standard bulky formulas applicable in a scientific test but of little value in the every day operation of a boiler plant.

In spite of several trials and the use of extreme cases he is unable to show much difference and even then it is a question which formula is correct. I cannot agree with him that it does not matter whether the heating surfaces are clean or dirty and that there is nothing gained by separating the loss caused by this condition.

I unhesitatingly reaffirm the correctness and practicability of the formulas and nothing that Mr. Darnell has said alters in the least the accuracy of the previous presentation.

Item 6 is not a controllable variable, hence does not greatly concern the operator. For steam grades of hard coal, however, I believe the figure as nearly correct as an assumed constant can be. Refer to an article by H. D. Fisher in the September, 1920, issue of Combustion and a confirmation of the table which I have given will be found. This table is the result of a great number of tests.

Item 7—It is difficult for me to understand why Mr. Darnell introduces the computation which he does, in a practical heat balance. Every constant he gives is subject to variation and the temperature of the radiating surface is not uniform. The difference method is surely more accurate and convenient.

In our plant a heat balance is computed very quickly each day by the method which was outlined in the Aug. 15 issue. We do not expect scientific accuracy; our object is to reduce operating losses to a minimum and our practice of calculating a heat balance each day, using the same method each time and readings from the same instruments, has been a wonderful aid in this direction.

A. W. Binns.

Correct Oiling of Refrigerating Machinery

Effect of Too Much Oil; Kind of Oil Which Should Be Used; Selection of Oil for Steam Cylinder. By John W. Stack*

ONE OF THE commonest causes for the falling off in efficiency and capacity of the ammonia compression system is the use of too much oil in the compressor. Oil in the condenser or expansion coils of a refrigerating system is just as detrimental as oil in a boiler. In the refrigerating system an oil film will reduce the heat transferring capacity of pipes and coils as much as 40 per cent. The ammonia compressor operates on a closed system on the same ammonia and since lubricating oil is added from time to time, suitable traps must be installed at points where most of the oil can be recovered. The principal function of the oil is to seal and lubricate the piston rod.

For horizontal compressors and for single acting vertical compressors, there is no need of pumping oil into the cylinder. There is probably enough carried around in the average system to be sufficient for the piston and cylinder. Double acting vertical machines may require a little oil in the upper end of the cylinder, though not more than 8 oz. in 24 hr. per 100 T. capacity need be used. A pint to one quart under the same conditions is sufficient for the stuffing-box. The operating temperature of the compressor has much to do with the quantity of oil used. If the discharge temperature is high more oil will be required. Periodic inspection of the cylinder and valves will determine the exact quantity of oil required for each compressor. Many large plants never use any oil in the cylinders and only a pint sight cup is used on the rod.

At the temperature and velocity of the gases during the compression stroke, the ammonia oil leaves in a finely atomized state and when the gas temperatures are abnormal, some of the oil will be so finely atomized it will be in a fog much like smoke. In order that this finely divided oil will recondense or form particles or drops large enough so they will drop out of the ammonia, the oil traps should be installed at points of low gas velocity and far enough away from the compressor to allow for some cooling. Oil traps should be blown down regularly. Oil should not be allowed to accumulate to more than one-half the capacity of the trap, otherwise the effectiveness of the trap is markedly decreased. The recovered oil should be checked against the amount put into the system as a measure of the condition of the pipes.

Quality of the Lubricant

Needless to say it is good business and sound engineering to use only the highest quality compressor oil, particularly adapted for the work. An ideal oil would be one with lowest temperature viscosity coefficient, or, in other words, an oil which would have but little change in viscosity at all operating temperatures. Since these temperatures range from 28 deg. F. to 350 deg. F. the oil should not congeal at the low temperatures and should not volatilize at the high temperatures. If the oil has a poor cold test it will congeal in the expansion coils and stick to the walls like grease. On the other hand, if the oil vaporizes too freely at the high temperatures it forms a foul gas and a heavy pitch-like deposit

*Lubricating engineer, Standard Oil Co. This discussion was presented at the convention of the National Association of Practical Refrigerating Engineers at St. Louis on Nov. 2.

and it also reduces the efficiency of the compressor by increasing the re-expansion at the start of the suction stroke.

Since some oil will pass by the oil trap, suitable oil besides possessing good cold test should not be too high in viscosity at the low temperatures obtained in the expansion coils. Thick or high viscosity oils will leave thick films on the pipe surfaces. A viscosity of 90 to 120 sec. Saybolt at 100 deg. F. has been found by practice the desirable body for large machines while the smaller splash lubricated machines seem to require a somewhat heavier oil, 150 to 170 sec. viscosity at 100 deg. F. This will take care of the bearings.

Such an oil should be a filtered, highly refined mineral oil, free from acid, animal or vegetable oil. Oil of this kind will not form permanent emulsions with moisture and ammonia and the resultant troublesome grease like deposits.

Small high speed ice machines with enclosed crankcase, in which the lubricating system is entirely incorporated within this crankcase, are growing in popularity. Since they receive little or no attention, as when the crankcase is filled with oil the machine is expected to run over long period without removal of the oil, two distinct lubricating troubles have developed with these machines—first, excessive foaming of the oil, and second, the formation of sludges in the crankcase. To a large extent these two troubles are closely related.

Examination of a number of samples taken from the crankcases of these machines have shown some of them in a solid state very much as the consistency of grease. This always resulted, of course, in mechanical troubles in the compressor, usually in the way of burned out bearings. Analyses of a number of these deposits show that they are largely composed of insoluble iron soaps. Typical analysis is the following: Iron soap, 70 per cent; insoluble organic matter, 21 per cent; iron oxide, 9 per cent.

Another deposit which completely filled the crankcase had the following analysis: Oil soluble in gasoline, 55 per cent; water, 26 per cent; insoluble matter, 19 per cent.

In these cases the insoluble matter is finely divided iron and iron oxide. The presence of iron oxide produces rapid oxidation of the oil and when this is combined with some moisture these soaps are produced. It can be seen, therefore, that nothing but highly refined ice machine oils can be used, which means oils that will separate from water freely (high demulsibility), and oils which will not decompose under heat. Evidently there must be some local heating in these units which accelerates this decomposition.

Lubricating Steam Cylinder

Factors effecting the selection of correct steam cylinder oils may be divided into three main classes, as follows: (1) Mechanical conditions which govern the determination of viscosity; (2) Conditions of application, that is, whether the oil is fed directly upon the surfaces to be lubricated or indirectly by feeding oil into the steam line; (3) Steam conditions, that is, temperature and the degree of moisture in the steam, which determines largely the degree of compounding required in the oil. All three of these factors are interconnected and must be judged together in making any selection.

Mechanical conditions, which take into account speed of the piston, weight of the moving parts and conditions of the surfaces, are largely the same problem as in bearing lubrication, other conditions being equal. For high speed and light duty lower viscosity steam cylinder oils are applied. On the other hand, for heavy duty, slow speed work the more viscous steam cylinder oils are used.

There are two general methods for introducing the lubricant into a steam engine, the direct method and the indirect method. In the direct method, the oil is pumped directly onto the cylinder and valve surfaces, while in the indirect method oil is injected into and atomized by the steam. The latter method is much more popular as it has been found more efficient and more economical.

In the indirect method the time element during which the oil is acted upon by the steam is largely a matter of steam velocity and the distance existing between the point of introducing the oil and the surface to be lubricated. Generally 2 or 3 ft. back of the throttle is the point of injection for good atomization of the oil. The heavy cylinder oils can readily atomize under these conditions, whereas if the oil is introduced at a point close to the cylinder, a lighter oil will be required in order to get the same degree of atomization. The secret of successful steam cylinder lubrication is thorough atomization of the oil, as by breaking up the oil into a large amount of minute particles better distribution is effected with a small amount of oil.

Classification of Cylinder Oils

Steam cylinder oils may be roughly classified as the dark colored or steam refined cylinder oils, and filtered steam cylinder oils which are deep red in color. The filtered steam cylinder oils lend themselves better to atomization for high speed work than the dark colored steam refined cylinder oils. It is not possible to obtain the same degree of lubrication in a steam cylinder that we get in ordinary bearing service. In the rotative bearing it is possible to keep all parts flooded with oil but such a condition cannot be maintained in the steam cylinder. The moving parts traveling in straight lines do not lend themselves to positions which will trap the oil so they can ride on a heavy film. As compared with rotative bearings the friction is very high in steam cylinders and valves. This friction may be from 10 to 15 per cent of the total power of the engine. The steam engine friction has been divided by Prof. R. H. Thurston in his valuable work on lubrication about as follows:

On a 21 by 20-in. condensing engine, main journals 46 per cent; piston and rod, crosshead and pins, 21 per cent; valve rod and eccentric, 21 per cent; air pump, 12 per cent. In a 7 by 10-in. high pressure engine the friction was found to be: main journals, 35.2 per cent; piston and rod, 16 per cent; piston rings, 6½ per cent; crossheads, crank and wristpins, 31.1 per cent; eccentrics and links, 8.2 per cent; slide valve and rod, no steam, 1½ per cent; 40 lb. of steam, 19.5 per cent. A 12 by 18-in. 100-hp. automatic engine showed this division: main journals, 41.6 per cent; valve and gear, including eccentric, 9.3 per cent; piston crosshead, crank and wrist pins, 49.1 per cent.

Steam, unless it is superheated, carries more or less moisture into the engine cylinder. This moisture may have been carried by the steam from the boiler or it may be due to condensation in the steam pipes. If the cylinder walls are wet with water it is very difficult to form an oil film on these surfaces. Steam cylinder oils, therefore, are usually compounded with fatty oil to make them readily emulsifiable with water. Compounded cylinder oils break through the water films and are not readily displaced by them.

American steam cylinder oils are compounded with from 2 to 12 per cent of various fatty oils although 5 per cent may be considered as the average for all types of cylinder oils. The greater the amount of moisture in the steam the greater the degree of compounding in the cylinder oil is necessary.

For a long time it was usually assumed that nothing but mineral steam cylinder oils could be used in an ice plant. Records show, however, that the majority of ice plants (and this is particularly true of the composite electric light and ice plant) are using compounded steam cylinder oils. By virtue of the fact that a much smaller amount of compounded steam cylinder oil is required to lubricate a cylinder, a great many engineers are using compounded oils in preference to the mineral oils. There is also a difference in the behavior of various fatty oils in the exhaust steam. Therefore it is possible to obtain especially compounded steam cylinder oils for ice plant service. The writer has seen a number of plants which were using compounded steam cylinder oils and getting clear ice. Where an oil trap of sufficient size is installed in the exhaust lines, and adequate filter capacity has been provided, and regularly cleaned, clear ice will be the result.

Oil will exist in the condensate either in rough or floating condition or in highly emulsified form, which, although showing no drops, produces a cloudy or opaque appearance in the water. This is due to the very minute division of the oil, these drops being visible only under a high power miscroscope. Larger particles or the roughly floating oil, can be readily skimmed off or separated in suitable drops. The amount separated in this manner depends upon the degree of compounding, and upon the temperature and velocity of the water. In some plants the writer has observed a coagulation effect. Oil would appear in the skimmer only in large slugs. Apparently the oil had been collecting in some part of the water system and when a sufficient mass accumulated had made its appearance in the skimmer. In this form, of course, it can be readily removed. Finely emulsified oil, however, is the oil which is responsible for the dirty ice. Very small globules of oil just seem to be waiting to attach themselves to some surface, and if iron rust or other solid matter is present in the water they will attach themselves to these and hold them in suspension and when the water is frozen will be evidenced as core.

Several patent methods for the clarification of these emulsions are based on the principle of supplying surface to these fine emulsions in the form of finely divided salts or iron oxides which can then be precipitated.

In order to detect the presence of oil in return lines, pipes should be so arranged that more or less of condensate can be drawn and tested at intervals for the presence of oil. The oil will show in water in either milky or yellowish emulsion, or may even float on the surface, in free state. Not infrequently an engineer will be very careful about the amount of steam cylinder oil used in his engine, while some oiler or boiler attendant will feed considerable more oil into the cylinder of a steam pump, or an auxiliary which is condensing into the general system. If it is desired to save this steam, suitable oil separators should be installed in all exhaust lines.

How to Tell When Lubrication Is Thorough

Examination of a well lubricated steam cylinder should show a hard, glossy surface, dark gray or blue in color, free from bright spots or streaks. The oil film on the cylinder and valves immediately after opening should be sufficient to penetrate four or five thicknesses of cigarette paper, and in operation the well lubricated engine will be free from excessive vibration, groaning or sticking of the valves.

Relative quality of cylinder oils is best tested on the engine itself. Under the same conditions of operation the best oil will require a reduced feed and upon examination, parts will be uniformly covered with a film of free oil. There should be no accumulation of pitch-like deposits on any of the surfaces not swept by the piston. In making comparisons it must be remembered that it may take some little time to replace an old oil film with a new. New oil should be started with higher feed than is customary on the engine, and gradually reduced to the minimum which may be found in operation by absence of vibration, and lubrication apparent on the piston rod, or by the slower process of indicating the engine and running free with different feeds of steam cylinder oil.

Occasionally a paste-like deposit will be found in some engines in the ports or counterbore. These deposits consist chiefly of dirt or foreign matter, such as boiler compound, clay, boiler scale or bits of packing held together by a very small quantity of cylinder oil. Simply dissolving these deposits in clean gasoline will disclose this fact.

Training Necessary to Analysis

Just as the trained surgeon with full knowledge of anatomy and practice in finding the best points in which to cut, and in cutting just right in depth and direction, can dissect much better than the tyro, so one who has learned how to analyze problems, and has had practice in doing this, can analyze better than one who is both untrained and untried.

The untrained dissector cuts at random; the skilled one severs or removes at first only groups of organs or members that he can separate further after they are removed or severed from the general system. So too with the analysis of the problems connected with a plant, an equipment, or a personnel; a job or a transaction. The job, for instance, is first separated into operations, each of which is analyzed further into times and motions. The transaction is analyzed into consecutive steps; for instance in the familiar case of a sale, into approach, securing favorable attention, exciting first interest, then appreciation and desire, next influencing decision and action, and finally "signing on the dotted line."

Robert Grimshaw.

Renewing a Main Engine Bearing

JUDICIOUS USE OF JACKS SIMPLIFIES REMOVAL OF BEARING PARTS. BY RECEIVER

IN SPITE of vigilance, oil, graphite and white lead, the babbit in one of the main bearings on a cross-compound engine burned out. When it was found that the metal had started, the engine was run slow with an abundance of oil for several minutes before stopping to prevent the babbit from adhering to the shaft and the possibility of the shaft being injured should it run on the cast-iron of the shells.

To remove the ruined bearing, the engine was stopped so that one set of arms of the wheel was horizontal or level, as shown in Fig. 2. The oil cups and oil piping

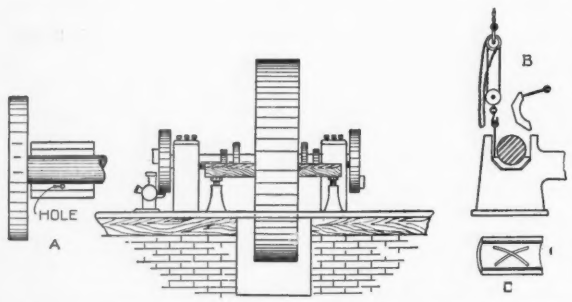


FIG. 1. ELEVATION SHOWING PLATFORM JACK UNDER CRANK DISK

with bearing cups were taken off the bearing caps and both oil guards completely removed from both sides of the engine.

Hard pine 8 by 10-in. blocking was run through the wheel parallel to the shaft in two columns with cross blocking as shown. On the side of the wheel toward the cylinder, the blocking was wedged solid against the arm after a piece of flat iron had been laid on the top block to prevent the arm bedding into the blocking.

On the other side of the shaft and on each side of the wheel, platform jacks were located with blocking on their caps as shown. House jacks were located under the crank desk which is farthest from the wheel to balance the thing up and assist in raising the load. Two husky men were put on each jack and the shaft and wheel raised about 2 in.

As no heavy round stock was available to make hooks to remove the bottom or cellar box, it was taken out this way: A screw jack and heavy block were placed against the crank disk and end of guide as shown at E, Fig. 2, and another jack D. When strain was put on these to counteract the belt pull the back quarter box was rolled over the shaft, up and out, as was also the other quarter, by putting a small screw eye in the tapped hole in the quarter box about the center of its length.

To drill a hole about ¼ in. in the side of the bottom box about the center of its length, an electric drill was used and the screw eye turned in, then the chain falls hooked on as shown at B, Fig. 1, and the box was turned over the shaft and out.

The shaft was thoroughly cleaned and coated with blue marking. The new quarter boxes and cellar box were then laid on the shaft in turn and rolled around to show the high places.

Having spotted the bearing, the markings were carefully scraped out, then the bearing returned to the shaft, and rocked and again scraped until a uniform bearing was obtained. Oil grooves were cut and the edges of the bearing chamfered off as shown in C, Fig. 1.

Again the shaft was carefully cleaned, also the oil pan cast in the pillow, and the oil drain. Then the bottom bearing was rolled over the shaft and into position, oil poured into the bearing, and the shaft lowered into place. Strain was again put on the jacks shown at E and D, Fig. 2, and the back quarter box put in place, then the front one and last the caps on each side of the engine.

When the caps were first taken off, a level was put on the shaft and the shaft was found to be level. When the bottom box was taken out, it was calipered from the bottom to the surface of the babbit and the new box also and found to be exactly the same. The shaft then had to be level. Had it not been level, shims would have been put under the low bearing or we could plane some off the bottom of the bearing as circumstances dictated.

All blocking was taken away, the oil guards replaced together with the oiling system and the engine slowly started. After a 10 min. run, the speed was gradually increased until full speed was obtained. After an hour's run with the temperature only slightly above normal,

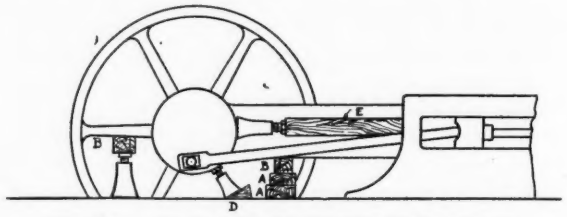


FIG. 2. JACK PLACED TO RELIEVE BELT STRAIN

it became evident that no trouble was brewing, so full load was put on the engine and as the bearings were taken up so the slightest pound was audible, no trouble has resulted.

Under-Water Cement

A STEAM or water pipe cement that will harden under water may be made from

2 lb. ground Paris white
5 lb. ground litharge
¼ lb. fine yellow ochre
¼ oz. hemp cut up small

Mix well with boiled linseed oil and use immediately.

C. C. BROWN.

AMERICAN INDUSTRY is spending about $70,000,000 annually on scientific research, according to the Fabricated Production Department of the Chamber of Commerce of the United States. About one-half of this sum is spent by American manufacturers in the conduct of laboratory research, while the remainder is expended in experimental and development work in plants, the department points out in a bulletin on research. As a result of scientific research work, it is explained by the department, approximately one-half billion dollars is being saved annually by industry in this country.

Commercial Stocks of Coal Approaching Normal

LATEST GOVERNMENT REPORTS COMPARE PRESENT SUPPLIES WITH PAST YEARS AND GIVE INDUSTRIAL AND TERRITORIAL DISTRIBUTION

AS WE are about to enter the season of the year when the consumption of coal is greatest, considerable anxiety as to the stocks of coal on hand in the yards of dealers and industrial consumers is noted, particularly in certain localities of the country where fuel must come long distances by rail or water. This year especially, both industrial and domestic consumers have been watching the coal situation closely and making certain, as far as possible, that they will not be

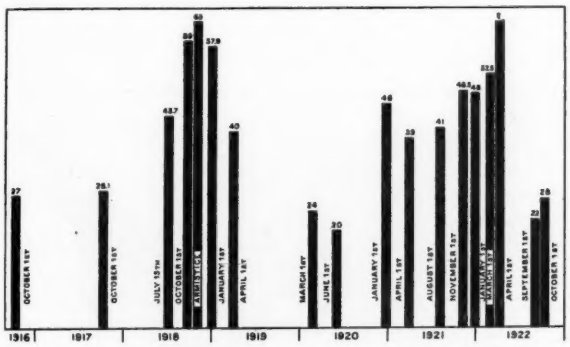


FIG. 1. TOTAL COMMERCIAL STOCKS OF BITUMINOUS COAL, OCT. 1, 1916, TO OCT. 1, 1922. FIGURES REPRESENT MILLION NET TONS AND INCLUDE COAL IN HANDS OF RAILROADS, INDUSTRIAL CONSUMERS, PUBLIC UTILITIES AND RETAILERS. COAL FOR STEAMSHIP FUEL, ON LAKE DOCKS, AND IN TRANSIT IS NOT INCLUDED. FIGURES FOR 1922 ARE SUBJECT TO REVISION

caught short when transportation becomes more difficult and there is a peak demand for coal.

To those who are responsible for the purchase of coal in large quantities the report of the Federal Fuel Distributor on the commercial stocks of anthracite and bituminous coal on hand on Oct. 1, will come as a bit of valuable information and guide in planning their purchases.

Commercial consumers, it is reported, had in storage on Oct. 1, 28,000,000 T. of bituminous coal, which is about the same as was on hand at the same date in 1916 and 1917; but measured in terms of days' supply the stocks this year are much higher, because the present rate of consumption is much below that of the years mentioned. In both quantity and days' supply the present stocks are higher than in 1920.

Estimates show that if this coal were evenly divided among consumers it would last for 22 days. It is of interest to compare this figure with others which are on record. The stocks on hand last April at the beginning of the strike were sufficient to last 52 days if evenly divided, as compared with 15 days' supply at the time of the low record in June, 1920. Stocks are, however, never evenly divided, for in every community there are consumers who keep almost no coal in storage, while others carry stocks far above the average.

According to the latest report on the production of coal, it is clear that the trend is upward and coal is being stored. Between Sept. 1 and Oct. 1, stocks increased 6,000,000 T. Since Oct. 1, they have increased at least as much again, if not more. On the Lake Docks, stocks which are regarded as coal in transit were 1,581,000 T., considered as very low for this season of the year. There is at least 540,000 T. held in storage at the mines or at intermediate points by the producers of coal.

Stocks of surplus coke at by-product coke plants have dropped to one-fourth of what they were last March. The quantity remaining on Oct. 1 was about 270,000 T.

Retail coal dealers' stocks of anthracite on Oct. 1 were the lowest at any time in the period over which stock records extend. Stocks on the Lake Docks were about 3 per cent of those of last year. There is little anthracite in the storage yards of the producers. Since Oct. 1, reserves have increased.

BITUMINOUS COAL IN HANDS OF CONSUMERS

SOFT coal in the hands of commercial consumers on Oct. 1, 1922, was between 26,000,000 and 30,000,000 net tons, probably, as stated above, 28,000,000 T. This does not include coal in the cellars of domestic consumers, concerning which statistics are not available,

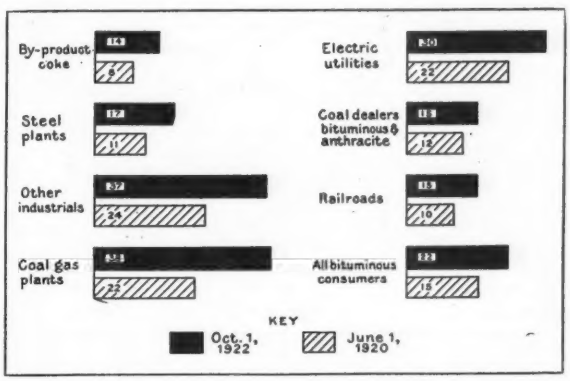


FIG. 2. DAYS' SUPPLY HELD BY DIFFERENT CLASSES OF CONSUMERS ON OCT. 1, 1922, AND ON JUNE 1, 1920. AT THE RATE COAL WAS BEING BURNED IN SEPTEMBER, 1922 (INCLUDING ALLEGED CURTAILMENT OF CONSUMPTION BY INDUSTRIALS), THE STOCKS OF SOFT COAL ON OCT. 1, 1922, WERE SUFFICIENT TO LAST 22 DAYS. AT THE LOWEST POINT ON RECORD—JUNE 1, 1920—THE STOCKS WERE SUFFICIENT FOR ONLY 15 DAYS. SINCE OCT. 1, STOCKS HAVE CONTINUED TO INCREASE

nor steamship fuel, nor coal on the docks at the head of the lakes, which is classed as coal in transit.

From Fig. 1 it will be seen that consumers began to stock in January in anticipation of the strike. By March 1, the reserve had grown to 52,500,000 T., and by April 1, it is estimated, to at least 63,000,000 T. On Sept. 1, 10 days after general resumption of mining in the union fields, the reports indicated stocks of 22,000,000 T. The strike of 1922 thus confirmed the experience of 1920 that when stocks fall as low as 20,000,000 T., high prices and anxiety result.

In the six months from March 1 to Sept. 1, 1922, it is estimated that consumption and exports approximated 195,000,000 T. Production and imports during the same period amounted to only 152,900,000 T., leaving a deficit of 42,100,000 T., of which 30,500,000 was drawn from consumers' stocks and 11,300,000 from the coal in transit.

Statistics, shown by classes of consumers in Fig. 2, are based upon reports of tons on hand and actual consumption from about 5000 consumers, so selected as to be representative of all commercial consumers. The rate of consumption used in calculating the days' supply on Sept. 1 and Oct. 1, was the quantity actually burned in September, 1922, except for certain industrial plants, coke ovens and steel works that reported curtailment of operation through lack of coal; for these plants the rate of consumption used was what would have been required to avoid curtailment.

Stocks by Localities and Types of Consumers

How stocks on Oct. 1 varied from state to state is indicated by Fig. 3. The map shows the days' supply held by industrial plants other than steel and by-product coke works, the largest group of consumers and the one most sensitive to changes in the coal market. The outstanding feature of the map is the heavy stocks carried in New England, where four out of six states report

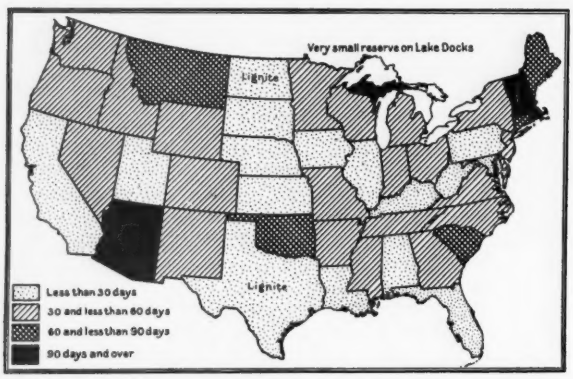

Very small reserve on Lake Docks
Lignite
Lignite
Less than 30 days
30 and less than 60 days
60 and less than 90 days
90 days and over

FIG. 3. DAYS' SUPPLY OF SOFT COAL ON HAND AT INDUSTRIAL PLANTS ON OCT. 1, 1922. AT THE ACTUAL RATE OF CONSUMPTION IN SEPTEMBER, STOCKS AT INDUSTRIAL PLANTS OTHER THAN STEEL AND BY-PRODUCT COKE WOULD LAST ON THE AVERAGE 40 DAYS. OUT OF 2107 PLANTS REPORTING, HOWEVER, 147 STATED THAT THEY HAD TO CURTAIL OPERATIONS IN SEPTEMBER FOR LACK OF COAL. AT THE RATE OF CONSUMPTION NECESSARY TO AVOID CURTAILING OPERATION, THE STOCK ON OCT. 1 WAS SUFFICIENT FOR ONLY 37 DAYS. HOW THE SUPPLY VARIED FROM STATE TO STATE IS SHOWN IN THE DIAGRAM

reserves in excess of 90 days. Over the country, as a whole, the average on Oct. 1 was sufficient for 37 days.

In comparison with Sept. 1, 1922, stocks on Oct. 1 show an increase in almost every state, except for the Gulf Coast district. In comparison with Nov. 1 a year ago, the states of the East and the Mississippi Valley show a decrease in stocks, but the states of the Far West show an increase.

Reports from 306 electric plants collected in part through the National Electric Light Association and American Electric Railway Association, indicate that on Oct. 1 electric utilities carried an average supply of 30 days. Into this average, however, went many plants with stocks much in excess of 30 days and others whose reserves were dangerously low. With few exceptions electric utility plants have less coal on hand than they did a year ago.

From the enormous total of 19,800,000 T. on April 1, railroad fuel stocks had declined on Sept. 1 to 4,560,000 T. During the month of September the railroads increased their stocks to 5,450,000 T., quantity sufficient to last them 15 days. Although lower than the stocks normally carried by the roads, this was much above the level to which they were reduced in 1920.

Because soft coal must replace any deficit in anthracite this winter, the reserves of retail coal dealers may best be reckoned as total tonnage of all coal, anthracite and bituminous, as is done in Fig. 4. Outside the

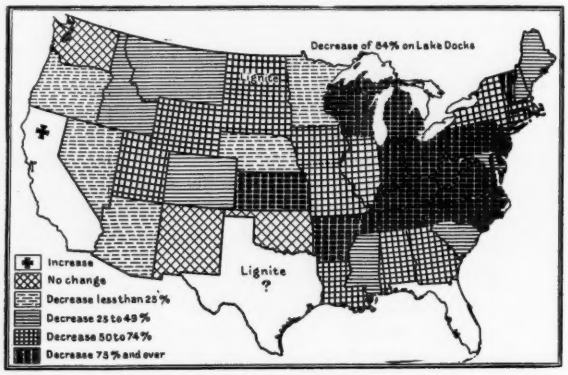


FIG. 4. HOW RETAILERS' STOCKS OF ALL COAL—ANTHRACITE AND BITUMINOUS—ON OCT. 1, 1922, COMPARED WITH THOSE ON NOV. 1, 1921. STOCKS OF BITUMINOUS COAL IN RETAIL YARDS ON OCT. 1 WERE ABOUT HALF WHAT THEY WERE A YEAR AGO. STOCKS OF ANTHRACITE WERE BARELY 13 PER CENT OF LAST YEAR'S STOCKS. THE TOTAL STOCKS OF RETAILERS—INCLUDING BOTH HARD AND SOFT COAL—SHOWED A DECREASE OF 67 PER CENT AS COMPARED WITH 1921. THE MAP SHOWS THAT THE DECREASE WAS SMALL IN THE FAR WEST, AND MOST ACUTE IN THE TERRITORY EAST OF THE MISSISSIPPI RIVER AND NORTH OF ALABAMA

anthracite burning territory the condition was as follows: In spite of a widespread increase during September, stocks on Oct. 1 were low. In comparison with last year (Nov. 1, 1921) they showed a general decrease. They were, however, higher than at the low point in 1920. The quantity of bituminous delivered by retailers to their consumers in September, 1922, was greater than in the same month last year, with certain conspicuous exceptions. In the coal-producing states of Pennsylvania, West Virginia, Kentucky, Ohio, Indiana, Illinois and the Southern Peninsula of Michigan, September deliveries of bituminous were smaller than last year.

Bituminous Coal in Transit

Coal in transit includes all coal brought to the surface, but not yet delivered to the consumer or retailer. The total in transit has never been measured, but it is known to run into many million tons and to fluctuate widely, depending on the quantity of coal leaving the mines. During the six months from March 1 to Sept. 1, 1922, there was an estimated net decrease in

the quantity in transit of 11,600,000 T., which amount went to help meet the deficit in production. Of this 11,600,000 T. 4,870,000 was taken from stocks on the Upper Lake Docks, 640,000 T. from unbilled loads at the mines, about 500,000 T. from producers' storage at the mines and intermediate points, and the balance from the coal en route in cars and vessels.

On March 1, 1922, stocks on the commercial docks of Lakes Superior and Michigan were 5,160,452 T. On Sept. 1 they had dropped to 292,140 T. In the month of September receipts by the dock operators so far exceeded shipments that their stocks increased to 1,581,391 T. on Oct. 1. In spite of the increase, the stocks are lower than at the corresponding date of any year covered by the published record.

These figures are exclusive of coal on private docks of industrial consumers, which coal is included under consumers' storage.

There were on March 1, 1922, 14,126 cars loaded with coal, but unbilled, lying on tracks at the mines, equivalent to 700,000 T. By Sept. 1, the unbilled loads had fallen to 1305 cars (65,000 T.). The peak accumulation of no bills was on April 8, when 30,730 cars, containing 1,530,000 T. of coal, were reported.

Last March a careful inquiry disclosed 753,000 T. in storage by the producers, of which 502,000 T. was at or near mines and 251,000 T. was at intermediate yards. During the strike this reserve was largely shipped out. Since Sept. 1, however, the few mines equipped to store have been stocking up and on Oct. 1 there was at least 540,000 T. in producers' storage.

Anthracite

Announcement that anthracite will be distributed on the basis of 60 per cent of last year's shipments brings home the fact that consumers must find substitutes for the remainder of their requirements. For the present, therefore, stocks of retailers in the anthracite-consuming territory must be reckoned in terms of all coal on hand, anthracite and bituminous.

While there are no statistics on the subject, it is clear that the total quantity of anthracite in the cellars of householders at this time is but a fraction of normal.

Stocks of anthracite in the yards of retail coal merchants on Sept. 1 were the lowest on record during the period over which these statistics extend. No complete count has been taken, but a selected list of 512 dealers, from whom reports have been received since 1919, carried only 10 per cent as much on Sept. 1, 1922, as on Aug. 1 of the year before. From Sept. 1 to Oct. 1, 1922, their stocks increased slightly, but were still barely 13 per cent of those at the corresponding season last year. At the rate of delivery made by these dealers to their customers in September, 1921, the stocks on Oct. 1, 1922, were sufficient for seven days. Since Oct. 1 production has been heavy and stocks have no doubt increased.

Reports received from retailers in the anthracite region indicate that during the month of September there was some replacement of anthracite with bituminous coal, but they also show that the replacement had not gone far enough to make up for the difference in the supply of anthracite. Thus a group of 180 retail dealers in New England, New York and New Jersey delivered twice as much bituminous to their customers in September, 1922, as in the same month of 1921, but because of the drop in anthracite their total deliveries of all coal fell 23 per cent short of 1921.

In the Lake Dock territory also there was an increase in retail sales of bituminous coal, offsetting in part the scarcity of anthracite. In the other states of the anthracite-consuming region, however, dealers delivered less bituminous coal than in the corresponding month last year.

Even if bituminous coal be included, the total reserve in the yards of retailers in the anthracite-burning region was below normal on Oct. 1. In comparison with Nov. 1, 1921, it showed a decrease of 67 per cent. From the map in Fig. 4, it will be seen that every state consuming anthracite reported a decrease in total retail stock of at least 25 per cent and that in many states the decrease exceeded 75 per cent.

Reserves of anthracite on the Upper Lake Docks, according to the Northwestern Coal Dock Operators' Association, had dwindled to 37,000 T. on Oct. 1, or barely 3 per cent of the tonnage on hand at this time a year ago.

November 1, 1921, the storage yards of the anthracite producers contained 1,768,000 T. of domestic sizes and 2,719,000 T. of steam sizes, a total of 4,487,000 T. Since then this reserve has largely disappeared.

Influence of Engine Speed

By Robert Grimshaw

How engine speed influences efficiency must be viewed from two standpoints:—

1. Rotation speed
2. Piston speed

and in both cases there are three kinds of efficiency to consider:

1. Mechanical
2. Thermo-dynamical
3. Financial.

As regards steam consumption per hour per horsepower at various rotation speeds, we have according to Denton and Jacobs, from a 17 by 30-in. non-condensing fixed cutoff Meyer valve engine:—

R.p.m.	8	12	16	20	24	32	40	48	56	72	88
⅛ cutoff, lb.	39	35	32	30	29.3	29	28.7	28.5	28.3	28	27.7
¼ cutoff, lb.	39	34	31	29.5	29	28.4	28	27.5	27.1	26.3	25.6
½ cutoff, lb.	39	36	34	33	32	30.8	29.8	29.2	28.8	28.7	...

The table shows the advantage, for a given engine, of

1. High rotation speed and piston speed
2. Early cutoff.

The question of piston speed alone, independent of rotation speed, must be considered with engines of different stroke length.

Correction Note

Attention has been called to two errors that appeared in the article, "Determining Money Value of Efficiency," on pages 1044 and 1045 of the Nov. 1 issue. The figures on the horizontal axis of the chart should be preceded by a decimal point and the division sign in the denominator of the formula at the end of the article should be changed to the sign of addition.

Turning a Crank Shaft Bearing in Place

THE WRITER was recently called to do some work on the main bearing of a Corliss engine. The shaft, 9 in. in diameter, had run hot. The babbit had melted and let the shaft run on the cast-iron shell of the bottom box. It was run this way for a couple of days, as the firm had a certain amount of work to finish.

There was only one way out of it, to turn down the journal, and as the engine was so situated as to make it a long and difficult job to take out the shaft and send it away, it was decided to try to turn it in place.

Machine shops in a neighboring city were visited and a long slide of a compound rest of a large lathe was borrowed. To this was attached angles of ½ by 4-in. flat iron, shown at A,A, Figs. 1 and 2, and these were fastened to the top of the engine bed. The slide was leveled and the necessary shims placed under the angles to keep it so.

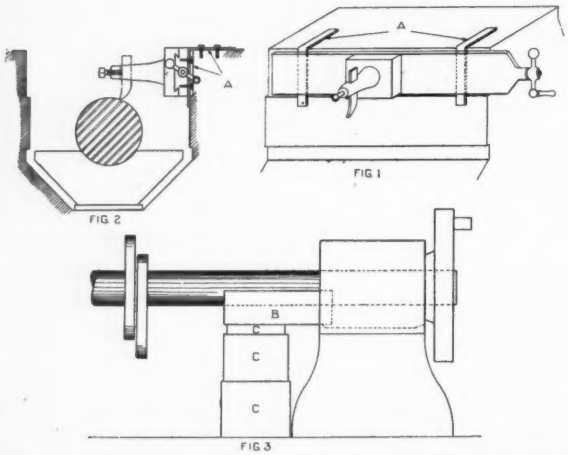


FIG. 1. COMPOUND LATHE REST ATTACHED TO ENGINE BED
FIG. 2. METHOD USED TO TURN DOWN SHAFT IN PLACE
FIG. 3. SHAFT WAS SUPPORTED DURING THE TURNING OPERATION BY THE BOTTOM BOX, SUPPORTED ON ONE END BY THE ENGINE FRAME, AND ON THE OTHER BY A PIER

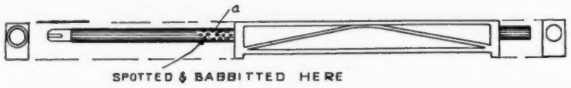
For a temporary bearing, the eccentrics were loosened and moved over on the shaft towards the flywheel as far as possible; the bottom box was then blocked up and babbit poured in, thus making a temporary bearing. Figure 3 shows box B partly resting in the jaws of the bed, and partly on blocks, C,C,C. The box B was wedged sidewise to keep from moving. Eccentric rods and connecting rod were removed, and also driving belt, from off the belt wheel. A small steam engine was belted to the flywheel to furnish the power necessary to turn the shaft. Several cuts were necessary for the job, after which the shaft was filed and smoothed up with emery cloth. The bottom and two quarter boxes were babbited and bored out, then scraped to the shaft. The engine was run slowly at first to wear in the bearings and when the load was put on the bearing ran well—better than was expected. TOM JONES.

Repair of Corliss Valve Rod

WHILE OVERHAULING one of our Corliss engines some time ago, we found the exhaust valve rods badly worn (at a) where the rods operate in the stuffing boxes.

To replace these rods with new ones would have entailed a great deal of time and expense, so it was finally decided to try to repair them.

This was accomplished by turning down the worn part of the rods to a depth of ¼ in. This area was then spotted with ¼-in. holes spaced ¾ in. apart and staggered all around the turned recess.



EXHAUST VALVE FOR A CORLISS ENGINE SHOWING WHERE THE WORN ROD WAS REPAIRED

A sleeve ¼ in. larger internal diameter than the rod was placed over the recess and babbit was poured in around the stem. Fire clay was put around one end of sleeve to keep the babbit from running when poured.

After the babbit was poured, it was allowed to cool then peened and turned to the original size of the rod.

These rods have been in service several months and are giving good results. W. A. FORD.

Using Pulverized Mine Waste

I AM much interested in the article in Power Plant Engineering of Oct. 15, page 1014, entitled "Pulverized Mine Waste Gives High Efficiency" and giving description of test from high ash and low volatile fuel in pulverized form in a French boiler plant.

Attention should be called to the fact that similar fuel has been burned in pulverized form quite extensively in this country for the last two or three years, using practically dust and culm mine dirt, etc., from anthracite coal. One large installation consists of six pulverizing screen mills for twelve 500 and 600-hp. boilers of the water tube type furnishing steam for a 10,000-kw. electric power station. It has been in successful operation over a year and a half and the owners are so well satisfied that they contemplate building another

similar plant in a different locality which will also use the same class of fuel. The efficiency of boiler and furnace of 80 per cent and over is maintained regularly, from the B.t.u. in the coal as fired, when developing 150 to 200 per cent of boiler rating.

Details given in the article in question are not altogether consistent and the statements are rather misleading unless they are clarified to such an extent as to make them more definite. For instance, in the sixth paragraph it is stated that average evaporation per pound of fuel is 7.38 lb. of water, which corresponds to an overall efficiency of 82 per cent for boiler and furnace. Figuring backwards, based on the B.t.u. in the coal of 10,728 per lb., 82 per cent boiler and furnace efficiency would give an evaporation of 9.06 from and at 212 deg. F. On the other hand, if the evaporation given as 7.38 lb. of steam is from and at 212 deg. F., this would mean only 66 per cent boiler and furnace efficiency. As the feed water temperature during the test and the boiler pressure are not given, it is difficult to interpret correctly the figures you give in the article.

FREDERICK A. SCHEFFLER.

On investigation, we find that the figure of 7.38 lb. of water is actual evaporation from water at 35 deg. F. to steam at 110 lb. gage pressure, thus giving the value of 9.06 for the evaporation from and at 212 deg. F., as Mr. Scheffler has calculated. Why such low temperature feed water was used, is difficult to understand. It certainly does not represent American practice and we can hardly conceive why such conditions were tolerated in the tests conducted at this French mine.—EDITOR.

Pumping Equipment

SINCE THERE ARE so many different compounds used which require to be pumped, and since there are so many different reasons why not all kinds of things may be pumped with one equipment, I feel that it is not out of place to present these tables of what may be pumped with pumps of various equipments, in the hope that they may be of service to someone. Reasonable attempts have been made to preserve them from error.

It may be well to mention that under the head "Materials," the classification is not that of the Hydraulic Society. By classification I do not mean table. They publish no such table, so far as I know. I do not doubt, however, that engineers will be able without difficulty to understand what is meant, even if they do not happen to be familiar with my form of classification, which is as follows:

All Bronze: Liquid cylinder, bronze; liner, bronze; piston rod, bronze; valve seats, bolts and springs, bronze; valves, bronze; water piston or plunger, bronze.

All Iron Fitted: Liquid cylinder, cast-iron; piston rod, steel; valves and valve seats, cast-iron; valve bolts and springs, steel; liquid piston or plunger, cast-iron.

Standard Bronze Fitted (standard fitted, when speaking of duplex pumps): Liquid cylinder, cast-iron; liner, bronze; piston rod, bronze; valve seats, bolts and springs, bronze; valves, rubber or bronze; liquid piston or plunger, cast-iron.

Full Bronze Fitted: Liquid cylinder, cast-iron; liner, bronze; valve seats, bolts and springs, bronze; valves, rubber or bronze; liquid piston or plunger, bronze.

I hardly think I need to add that the following table applies wholly to reciprocating pumps of the various kinds.

PUMPS USED FOR VARIOUS LIQUIDS

ALL BRONZE

Acetic Acid	Sebacic Acid
Acid Mine Water	Stearic Acid (hot)
Bitter Mineral Water	Sulphide of Hydrogen
Distillery-wort	Sulphuric Acid (common)
Glycerin	Sulphurous Acid
Hydrochloric Acid	Tannic Acid
Iron Pyritic Acid	Vinegar
Mash	Wine
Milk	Whiskey

ALL IRON FITTED

Alkaline Water	Cyanide of Potassium
Anilin Water	Ferrous Chloride
Aqua Ammonia	Green Vitriol
Benzene	Guncotton Brine
Beet Juice	Hot Oil (over 300 deg.)
Brine (calcium)	Lard (hot)
Carbonate of Soda	Lime Water
Caustic Carbonate of Soda in Sol. (hot)	Lye (caustic)
Caustic Chloride of Magnesium (cold)	Lye Solution (containing sand)
Caustic Cyanogen in Solution	Nitric Acid (diluted)
Caustic Manganese in Solution	Petroleum
Caustic Potash Solution	Petroleum Ether
Caustic Potash Niter in Solution	Pitch (hot)
Caustic Soda Solution	Potash Solution
Caustic Sodium Chloride Solution	Purifying Oil
Caustic Zinc Chloride Solution	Rosin (hot)
Chloride of Potash Solution	Soap Water
Coal Tar Oil	Soda
Creosote Oil	Sodium Sulphate
Cresol	Strontia in Caustic Solution
	Sulphite of Soda (hot)
	Sulphuric Acid (concentrated)
	Tar (hot)
	Turpentine Oil
	Vegetable Oil

STANDARD BRONZE FITTED

Alcohol	Mineral Oil
Benzene	Naphtha
Bisulphite	Olive Oil
Brine (sodium)	Paraffin
Carbonic Acid	Pulp
Cyanogen	Rape Oil
Gasoline	Sirup
Grease (hot)	Sodium Chloride Solution
Hot Oil (300 deg. maximum)	Sugar Compound
	Sugar Solution
Heavy Oil	Sulphate of Lime
Linseed Oil	Toluol
Lye (salty)	Water

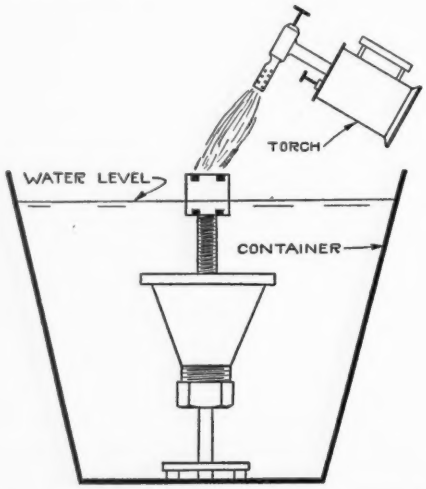
FULL BRONZE FITTED

Cane Juice	Salt Water
Glue (hot)	Sea Water
Molasses	Sewage

GEO. F. SWETNAM.

Repairs of Ammonia Valves Having Soft Metal Inserts

OCCASIONALLY the engineer is troubled with leaky ammonia valves caused by scale lodging between the valve seat and the soft metal insert in the disc when the valve is being closed. Leaks may also result when a valve is closed frequently, with unnecessary wrench power, causing the soft metal to compress sufficiently to allow the iron body of the disc to come into direct contact with the seat.



VALVE DISC IS PARTIALLY SUBMERGED TO KEEP ONE SIDE COOL WHILE THE OTHER IS BEING REFILLED

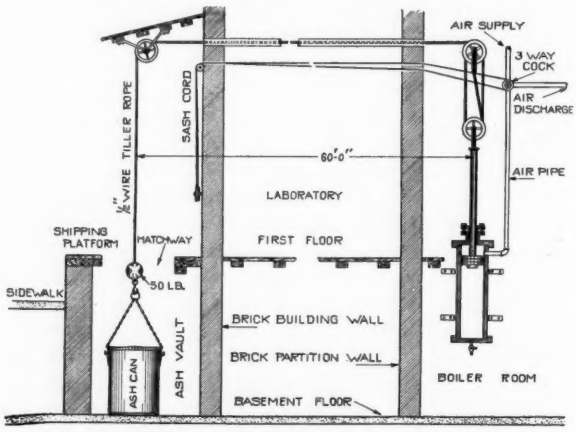
Generally these discs have seats on both sides in order to back seat when the valve is open so that the spindle gland may be repacked without pumping down the system. These back seats seldom give any trouble.

I had a few of these valves to repair recently, and in order not to run the soft metal in the back seat while I was melting out the main seat, I placed the valve bonnet in a vessel of water as shown in the accompanying illustration; with the water level at about the middle of the disc, I was able to apply a torch to the top side and thus add new metal without fear of also melting the insert on the back side. After the new metal had been added, it was scraped down in the usual way to fit the valve seat.

AUGUST GASS.

Handy Device for Handling Ashes

IN A CHEMICAL works, the boilers were located near the center of the building, and the ashes had to be wheeled by a round-about way to the front, shoveled into cans, and hoisted with block and falls through a hatchway in the shipping platform, and dumped into a cart. It was rather a laborious job, and the engineer devised a scheme for handling the ashes, which was a great improvement on the old way. With material on hand, a device, such as shown in the accompanying sketch, was installed. A piece of 6-in. pipe was used for an air cylinder. This was capped at both ends, the top end being drilled, and tapped for a homemade stuffing box. A plunger was made of three 6-in. rubber pump-valves, with an iron plate top and bottom to hold them rigid. A grooved sheave was attached to the end of the plunger-rod, another, at the ceiling, and still another, under the awning over the shipping platform. To avoid dragging any dust into the laboratory, a 1¼-in. pipe was run through, for the wire rope to travel in. One-half inch tiller rope was used for the hoisting cable. Air pressure at 15 lb. was available, and a ½-in. pipe was run to the cylinder, with a three-way cock near the ceiling. On the stem of this cock, a sheave was secured, and a sash cord wound on it, one



DIAGRAMMATIC ARRANGEMENT OF ASH HOIST

turn, and carried through the walls in small tubes set in the brickwork, then over small rollers at the outside of the building wall, and led down to a convenient height for operating. A valve in the air supply was closed when the hoist was not in use, to prevent tampering with the device. Instead of wheeling the ashes, and dumping them, to be again shoveled into cans, the cans (holding 150 lb.) are now filled at the boilers and taken on a truck to the ash vault, where they are hoisted out with the machine. It was found necessary to add a 50-lb. weight to the empty can, as shown in the accompanying diagram, to assist in hauling the cable, and raising the plunger in the cylinder, as the discharge of air from the cylinder was too slow. This device has been in daily use for a number of years, and has been found to work quite satisfactorily.

M. M. BROWN.

Why the Tank Leaked

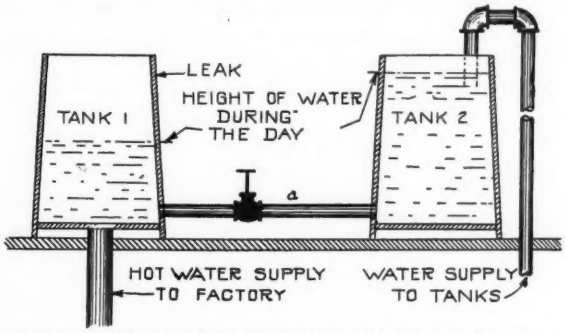
IN A MANUFACTURING plant where they have two hot water tanks in use which are made of wood, the water is used for manufacturing purposes.

It had been noticed for some time that No. 1 tank, as shown in the illustration, had been leaking during the noon hour and nights when both tanks were full of water. The leaking of the tank would last for a few hours, then stop. Nobody paid any attention to this until the leak got worse. When an examination was made, it was found that the tank staves at the top had dried out. The tank bands were driven down to stop the leaks and no more attention given to the matter.

Leaking kept on noons and nights as before. This was a puzzle, until finally the cause of the trouble was found. It will be noticed in the illustration that cold water from the city main runs into tank No. 2, then

through pipe *a* or equalizer pipe into tank No. 1 where the water is heated by steam. From tank No. 1 the hot water is run into the factory and used for manufacturing purposes.

One day while making some changes in a number of the pipes near the tank, it was noticed that tank No. 1 was only partly full of water most of the day, whereas it should be nearly full. Tank No. 2 was nearly full of water. In thinking the matter over it was decided that pipe *a* must be partly clogged up, which would not allow sufficient water to run into tank No. 1 to keep the water at the same height as in tank No. 2. No shortage of water was noticed in the factory, and



CLOGGED PIPE BETWEEN SERVICE TANKS CAUSES LEAK

No. 2 tank gage showed that this was always nearly full of water so not much attention was given the tank on account of the leak; there was no gage on tank No. 1.

As tank No. 1 was partly empty most of the day, and being in a very hot place, the tank would dry out at the top during this time and then during noon or at night when no water was taken from the tank, it would fill up and leak until the staves were tight again after a few hours.

At the first opportunity the water was run out of both tanks and pipe *a* was examined, when it was found that a piece of wood had gotten into the pipe in some way, partly clogging it up. After this was removed, there was no further trouble with tank No. 1 running partly empty. H. A. JAHNKE.

The Commutator

THE ARTICLE in the Aug. 1 issue, "The Commutator," by J. B. Dillon, brings to mind some experiences with the undercutting of commutators. We had several direct current generators of various sizes. Two 200 kw. units doing street railway service with short but frequent overload peaks gave us plenty of trouble with sparking and burning. Our habit here was to wipe the commutator frequently with a cloth moistened with oil. This was bad practice, as it softened the mica between segments and caused holes to burn in between the segments. By using nothing on the commutator, we obtained the least trouble.

We also slotted the commutators, and for a time it seemed to help, but finally the trouble was aggravated as the slots became filled with dust and carbon. The generator ran at slow speed and the centrifugal force was insufficient to keep the slots free from accumulated dirt.

We trued up the commutator on a small exciter generator, 1400 r.p.m., and when we tried to put it to work, it failed to generate. After two days testing and trying to locate the trouble, we found that the mica was high and that the brushes rode the mica and did not make contact with the commutator, hence no current. A little sandpaper on a block of wood applied to the commutator remedied the trouble.

We also had a 500-kw. motor generator set, 720-r.p.m. synchronous motor, on street railway bus which had the most beautiful chocolate brown color and gave no trouble whatever, but the superintendent came along one day and ordered the commutator on this unit slotted. Several of us tried to persuade him to rescind the order, but he would not hear of it. Accordingly the commutator was slotted and our trouble started. Sparking, chattering and burning of the commutator continued until we wore the slots out. Now the commutator is working nicely again. This was a case where it would have paid to let well enough alone. Slotting commutators is recommended when other remedies fail to accomplish results. Do not slot commutators that are giving reasonably good service. Avoid all lubricants and commutator dopes as much as possible, and use a good natural fine grain stone occasionally. C. E. N.

Resistance in Shunt Winding to Increase Motor Speed

NOT LONG AGO we found it necessary to remove for repairs the 10-hp. compound wound motor used for driving one of our sewing machines. In order to keep the machine in operation, we borrowed a similar motor from the concern that was doing the repairing; however, when this unit was installed, we found that the speed was too low to operate the machine properly. We called in the superintendent of the repair company and asked him what he could do to help us out. He said he thought he could increase our speed by about 200 r.p.m. by putting a rheostat in series with the shunt winding to weaken the field strength. Since he made this change we have had no trouble in keeping up to speed. L. F. BRYAN.

Handling Asbestos Washers

OPENING his washer till, the old garage mechanic took out a black washer.

"What, you aren't going to put a hard rubber washer on there, are you? ejaculated the car owner.

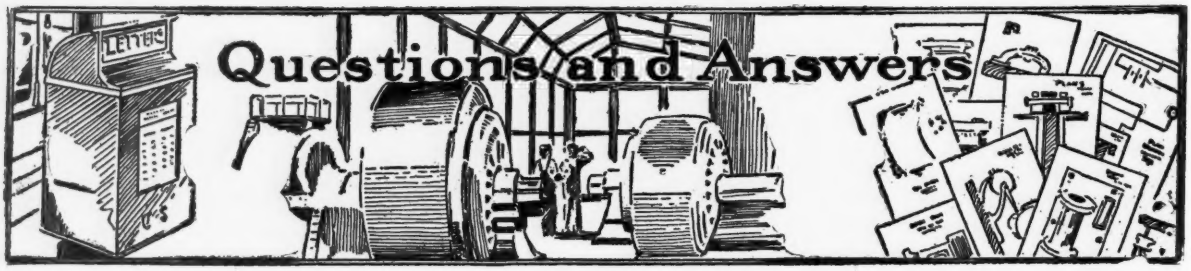
"Nope, asbestos."

"Why I never saw any black asbestos."

"Well, you see you orter always treat asbestos washers before using 'em. I soak 'em in olive oil for about a day, let 'em dry and then I rub 'em with black lead and lay 'em away until I need 'em. By doin' that I get a good tight fittin' washer and when they are taken off they come away without hanging fire, you don't have to pry 'em off."

Sounds reasonable, doesn't it? J. B. DILLON.

THIRTEEN DIESEL ENGINES will furnish the power for pumping for a pipe line which the Sinclair Pipe Line Co. is building between Tulsa, Okla., and Chicago. There will be six 365-b.hp., one 520-b.hp. and six 750-b.hp. engines in the power layout. Busch-Sulzer Bros. Diesel Engine Co. has secured the contract to furnish the engines, and work on the units has already begun.



Condensation in Heating Coils

WILL YOU kindly give me the approximate condensation in pounds per 100 sq. ft. of heating surface per day of 24 hr. in a well constructed frame mill, where a large room is heated with a coil of common pipe containing about 700 sq. ft. of surface and where the temperature is maintained at 50 deg. F.? The steam pressure in the system is kept at 20 lb.

What will be the condensation in an underground pipe laid through 4-in. tile 1½ ft. below the surface? The outside temperature here reaches as low as — 30 deg. F., and the ground freezes to a depth of 4 ft. The average temperature during the months of November, December, January and February is about 20 to 25 deg.

J. S.

Tapping Out Hole for Internal Feed Line

NOT LONG ago during an inspection of our Heine boiler, we found the internal feed line adrift in the shell. Due probably to the feed water which we had been using, the threads on the pad were corroded to such an extent as to be beyond repair and we found it necessary to tap out a new hole. To anyone acquainted with the construction of this boiler it will be apparent that there is not much room to handle a 2½-in. tap inside the shell owing to the fact that there are baffle plates in the way. A tap of this size requires the application of a considerable force to make it take hold and in this cramped position it proved an almost impossible undertaking. It would seem that there should be an easier method of making this repair. Can you suggest an easier method that we can use should we again be confronted with this problem?

A. The Heine Boiler Co. has used two methods of connecting the internal feed pipes in their boilers. Originally a nipple with an extra long thread was inserted from the outside of the front boiler head. The long thread extended through the head about 2½ to 3 in. The internal pipe leading to the mud drum was then connected to this by means of an ordinary coupling. Inasmuch as the connection is on the inside of the boiler this joint did not have to be steam or water tight, the only requirement being that the joint should not come loose of its own accord.

The second method used, particularly in recent years, is to rivet a flange on to the head or shell wherever the connection is made. This flange is tapped from both inside and outside. The external feed pipe is screwed into place then the internal pipe screwed into the inside face of the flange.

It should be possible to insert a new pipe in either of the above cases without any special tapping, unless perhaps the inside threads have corroded or have been eaten away by action of the water. Should this latter be the case, a long running thread on a nipple from the outside would be the easiest way of making the repair, or the old flange could be removed and a new one riveted in place.

HEINE BOILER CO.

Cost of Steam Leaks

WE HAVE in our plant a large crank type fire pump, which is used, of course, only in case of emergency. On an inspection, recently, we found a leak through the main steam throttle valve that, when condensed and measured, amounted to about a quart of water a minute. I would like to make a report of this condition, indicating the amount of coal wasted during the course of a year to supply this loss. We use a fairly good grade of soft coal and heat our feed water to 100 deg. F.

A. In order to determine the amount of coal used to supply this loss, it will be necessary to know the heating value of the coal used, the overall efficiency of your boiler and furnace, the steam pressure, and the feed water temperature.

As the leakage amounts to 2 lb. of condensed steam per min. (which is approximately 1 qt. per min.), or 120 lb. per hr., the daily loss is 2880 lb. and the yearly loss, about 1,050,000 lb. If we assume that the steam pressure is 150 lb. gage, the total heat per pound is 1195 B.t.u. and the heat added per pound with 100 deg. feed water will be $1195 - 100 + 32 = 1127$ B.t.u.

Assuming that the coal you use has a heating value of say, 13,000 B.t.u. per lb. and that your boiler operates with an efficiency of say 65 per cent, then your evaporation will be $13{,}000 \times 0.65 \div 1127 = 7.5$ lb. of steam per pound of coal. The coal consumed to supply this waste is then $2880 \div 7.5 = 394$ lb. per day. In a year this amounts to 140,000 lb. or 70 T. The yearly cost can, of course, be found by simply multiplying this figure by the price of coal per ton.

This solution assumes that the steam escapes to atmosphere and that therefore it is a total loss. As a matter of fact, it is likely that the steam blows directly into the exhaust system, in which case the total heat of steam at the exhaust pressure, or at least that part of it not lost by condensation in the pump cylinder, may be recovered. The amount of heat thus lost will depend upon the size of the pump cylinder, whether or not it is lagged, and on the room temperature. This loss can be found only by actual measurement of the condensate from the cylinder. If the exhaust and condensate is saved in this way, the loss will, of course, be greatly reduced. It will be well to call attention to the fact that for fire service where a pump is likely to be needed at an instant's notice, it is the general practice

to allow a small amount of steam to blow through at all times so that the pump will be kept heated up and ready for instant service. In this case the loss of steam can not be charged against inefficiency of operation, but must instead be charged to fire insurance.

Reduction in Allowable Boiler Pressure Due to Corrosion

On a recent inspection of a horizontal return tubular boiler, we found a corroded section extending along the longitudinal seam for a considerable distance. The greatest depth of the corrosion was about 3/16 in. The original thickness of the plate was ½ in. and the efficiency of the longitudinal joint is 86 per cent. Would a pressure reduction on this boiler be necessary or advisable? If so, what should be the percentage of reduction? G. P.

A. If corrosion has reduced the thickness of your boiler shell by 3/16 in., then the thickness of the remaining portion is 5/16 in. and the strength as compared with the original plate is $5/16 \div ½ = 62.5$ per cent. As this is less than the minimum efficiency of the longitudinal joint, the maximum allowable pressure will have to be reduced to maintain the original factor of safety. The reduced pressure will be $62.5 \div 86 = 73$ per cent of the original. This of course means a reduction of 27 per cent.

Lap on Corliss Valve

In answer to B. S.'s question on page 1072 of the Nov. 1 issue of Power Plant Engineering on Corliss valves, I submit the following:

1. What is the definition of lap on the Corliss valve? The lap that is necessary to consider is the amount that the valve overlaps the port when in central position, and the dashpot hooked on. (There are some who set valves without being hooked up.)

2. How is it measured? There is a mark on the end of the valve which corresponds to the opening edge, and also one on the end of the valve cylinder that shows the edge of port. Measure the distance between these two marks with valves hooked up and in central position.

3. Why is it that there is no steam lap required on the double eccentric Corliss engine while on the double eccentric Greene engine lap is necessary? The Greene steam valves are of the multi-ported type grid iron valves, moving in and out of the cylinder, lengthwise. They are opened by means of a sliding table, which carries tappets that are raised and lowered by the governor, thereby controlling the cutoff. These tappets engage hanging toes which move the valve by means of crank and rock shaft and valve stem. After being carried so far, the toes and tappets disengage, and the steam pressure on the end of the valve stem closes the valve, and, being cushioned by the dashpot, the valve comes back to the same position that it started from and remains there until the toes and tappets engage again. If there were no lap, the ports would be open all the time, as the hanging toes might be at right angles to the sliding table when disengaged. The Corliss is a semi-rotating valve and even if set with no lap when it is unhooked, the valve having plenty of overlap, as the dashpot goes down the valve rotates farther and then when it is hooked on it travels some distance before it gets to central position. This shows that with the Corliss double eccentric engine set with negative lap the steam will not blow through, while with the Greene if set with negative lap the valve would never close.

L. N. W.

Preventing Water Hammer; Adjusting Safety Valves

In the November 15 issue on page 1124 W. S. S. inquires as to what causes a water hammer in his boiler feed lines. No information is given as to whether he is pumping from an open or through a closed feed water heater. In my opinion, what causes the water hammer is the mixing of cold and hot feed water. Assuming he is pumping through a closed heater and that the cold makeup water enters at some point on the suction line and also the condensation returns from the heating system may enter close and at the same point the cold makeup water and the hot water returns coming in contact would cause a water hammer.

In my plant I had trouble with water hammer in the suction line. At the point where the cold makeup water entered, a nipple had to be renewed every six weeks because hot returns entered at the same point. This was caused, of course, by unequal temperatures aided by a water hammer. To overcome this trouble, we had to install a pump governor and receiver. By this method, the cold makeup water and the hot condensation water had a chance to mix thoroughly in the receiver before entering the suction line to the feed pump, giving a uniform temperature and eliminating the water hammer.

On the same page an inquiry is made concerning four water-tube boilers, each 333 hp., equipped with two 4-in. pop safety valves on each boiler and that those safety valves blow at various pressures even though they are all set to blow at an equal pressure on all the boilers. I will say that water-tube boilers are quick generators, but, on the other hand, the pressure will drop just as quickly if they do not get strict attention by the fireman or operator on account of the small amount of water space allowed on those boilers. For instance, if all the boilers are connected together and the fire on each boiler is burning at the same temperature, if the fireman covers one of those fires with a heavy charge of green coal, the pressure in the latter will drop below that of the others.

I advise the writer to have those boilers fired up equally or as nearly so as possible. Then, assuming that there are tension springs on the pop safety valves, when one of the valves begins to simmer before its set pressure is reached, tighten down on the tension nut which is set at the top of the spring. Repeat the same process on each of the other valves until you get them blowing all at the same pressure. But before this method is adopted examine carefully the nuts and spring bolts, as they may be rusted or crystallized. Those nuts should be examined when the boilers are not operating, as it is dangerous to meddle with them with such high pressure in the boilers. Keep an equal temperature in your furnace, fire light, keep the water at the same level on each boiler and install a good damper regulator, and your troubles will be ended.

P. J. Molloy.

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Progress in Refrigeration

There are few applications of modern engineering practice which affect the comfort and well being of the public more than that which is exemplified by the work of the refrigerating engineer. Indeed, it may be said that the growth of this industry and the widening of its scope is one of the amazing developments of the past few years.

Beginning on a small scale, at first, for the cooling of rooms wherein perishable goods were kept and for the production of ice, refrigeration has expanded rapidly, until today the work requires the services of highly trained engineers.

Air conditioning alone offers an enormous field of possibilities, both along industrial lines and in public building work. The theatrical people have recognized the value of this application and many of the theaters now include such apparatus. Even so, the work is yet in its early stages and much is to be learned regarding the production of artificial atmospheric conditions which will give a feeling of personal comfort. Studies of inside temperature gradation with respect to outside temperatures and humidity, and the psychological and physiological effect on the individual, must be studied in this connection.

Besides the increasing number of applications there are the engineering details of design and operation. Multiple compression, high speed compressors, use of oil and uniflow engines, electrification, and most efficient methods of ice making are just a few of the points upon which engineers are now concentrating.

To show the keen interest in the development of refrigerating engineering, the convention of the National Association of Practical Refrigerating Engineers at St. Louis on Nov. 1 to 4 may be cited. Some 500 engineers from all sections of the country, gathered to discuss the practical features of the work. No less important will be the meeting of the American Society of Refrigerating Engineers in New York on Dec. 4 to 6.

Just what the future holds for the refrigerating engineer will be largely determined by the work of such organizations. Every indication seems to point, however, to continued progress in this field which, though not new in itself, has far outgrown the bounds of its original limitations.

Coal Production Limited by Transportation

No one factor is so important to the power plant industry today as the fuel situation. During the past few years, almost an entire revolution has taken place in regard to the kinds of fuel used. Throughout practically the entire country, boiler furnaces have been redesigned so as to accommodate fuel which seemed most certain of supply.

All the lower grades of coal have been called into use. Factory refuse is being burned more than ever before. The high prices of coal are even making practicable more extensive use of oil, which heretofore has been entirely out of the question as fuel for steam generation except in specially favored localities.

Having been forced through these changes, and with the country on the verge of a fuel panic in August, it is with considerable relief that the industry can view the present coal situation. In view of the condition of

transportation facilities and the somewhat limited production of coal since the mines resumed operations, the efforts of the Government to secure an equitable distribution of coal throughout the country and among the industries are indeed commendable. The danger of local shortages is not entirely over yet, but with weather comparable to what has prevailed during the fall months, the fuel situation would seem to be much better than could have been hoped for early in September.

According to the report of the Fuel Distributor, the electric utilities of the country had an average of 30 days' supply on hand on October 1. This is low, particularly for this time of the year, as most utilities aim to carry about 90 days' supply in storage, but since these figures were collected we have had two months of good weather which has given an opportunity to increase this reserve.

While during the summer months when coal should, for economic reasons, be accumulating for winter use, the strike of the miners limited the production to about one-third what it should be, the limiting factor at the present time, in fact ever since the miners resumed work in August, is the shortage of transportation facilities for carrying the coal from the mines to the points of consumption. As a matter of fact, the bituminous mines are today operating at less than 50 per cent of their total capacity, the per cent lost on account of the transportation disability being the only cause of loss in production of any consequence in the principal coal mining districts of the country.

Although this shortage of cars at the mines has been aggravated this fall by the present demand for coal, it has been the limiting factor in the production of coal for a number of years and until transportation facilities have been increased, the country may expect unstable marketing conditions in the coal industry.

Off Duty

Off duty again, eh! Well, now, we'll admit that sounds pretty good to a set of hard working fellows like us; but, gosh, we don't know whether we can afford to stop and loaf. This little old planet of ours is moving so fast these days that it takes nearly all of a fellow's waking hours to keep up with it.

Take, for example, the field of electrical engineering. Here was a field that had developed by leaps and bounds. From Volta's experiments on frogs' legs or even from Edison's first electric lamp to our present day electric locomotives and 70,000-kw. generators was a long stretch—not so much in years, but in the wealth of development that characterized the time interval. The principles of electric engineering had become pretty well established in that time. Now, after 30 yr. of rapid development, we were just beginning to think of taking a rest—we knew all about motors and generators and synchronous converters, and had most of Steinmetz's equations down pat.

To tell the truth, we thought we knew about all there was to this business of electricity when in 1913 along comes a bright young chap by the name of Millikan, who says: "Halt! behold! here in my laboratory I have captured an electron." Just like that, all of a sudden-like. Of course our curiosity was excited and we eagerly looked to see what this new animal he had caught looked like; but, gosh, we couldn't even see it, it was so small. Well, Millikan says it's there and tells us it is about two-tenths of a thousandth of a millionth of a centimeter in diameter. And we believe it, for Millikan says so, but we go away thinking that that poor little electron will never amount to much, and as we pat ourselves on the back because we know so much about electrical engineering, we proceed to forget all about the little electron.

But the scientist didn't forget—no, sir, he just took that little fellow and put him through a course of gymnastics that made a whirling dervish look like the hour hand on a Big Ben, and before we realized it, that little electron was telling the world about himself. For it is that same little electron that Millikan isolated in the laboratory that is today broadcasting our voices and music over the entire face of the globe.

That same little electron enables us to penetrate the atom and to determine its structure. It was a young Oxford scientist by the name of Mosely who first showed the world how to make the electron reveal the secrets of the atom. Up to the time of Mosely's researches, nobody had ever seen the inside of an atom. Mosely turned the X-rays on matter and made them disclose the skeleton of an atom just as certainly as a surgeon makes them reveal the position of the bones of the body.

Mosely is dead. He was shot and killed instantly at Gallipoli in the summer of 1915, a victim of the most ghastly crime in history, the world war. He was only 27 yr. old, but at the time of his death he had accomplished as notable a piece of research in physics as has appeared during the last 50 yr. Yet, this brilliant young mind was sacrificed upon the altar of war. What the world lost by Mosely's untimely death, it will never know; but what it gained during his brief young life it can never forget.

Today, the work that Mosely started is being continued in the world's foremost research laboratories. In these laboratories, the electron reigns supreme.

Not content with projecting our voices through the almost illimitable vastness of the earth's atmosphere, the electron carries our power from remote rivers and streams where it is generated to our towns and cities. To be sure, it did this long before we knew that there was any such thing as an electron; but today we are capable of utilizing its powers in an entirely different manner from that used in older electrical engineering.

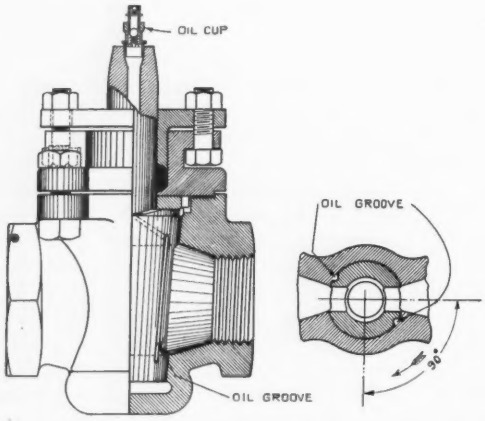
Whether the day of the synchronous converter and the high tension alternating current transmission line is nearing its end, giving way to the kenotron rectifier and direct current transmission is a question which must still remain unanswered. There is no doubt, however, but that we are on the verge of a new era in electrical engineering in which the vacuum tube and the electron will play the leading roles.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Lubricating Feature Added to Homestead Quarter-Turn Valves

THE TREND of steam pressures in power plants and also in the various industrial processes, such as oil refining, chemical industries, etc., has been in the direction of higher pressure and higher temperature. As a result, the problem of securing valves which are suitable under these conditions has been a perplexing one and the manufacturers of valves and



GROOVES CARRY OIL TO SURFACE OF PLUG IN LUBRICATED QUARTER-TURN VALVE

fittings have adopted various means of taking care of the new condition.

It has been found necessary to adopt some method whereby a lubricant could be used and constantly renewed to meet some of the extreme cases. This lubricant introduced on the seating surface of the valve protects the metal from corrosion and the action of high temperature as encountered with superheated steam. It insures easy operation, and a tight valve when shut off.

After more than 2 yr. of experimentation, the Homestead Valve Mfg. Co. recently announced that a series of valves, which used this principle of lubrication, had been developed.

These lubricated valves resemble the regular quarter-turn valves in that they are of the plug cock type, opening and closing with a quarter-turn of the handle. In addition, the seat is protected at all times by a film of oil which prevents the fluid in the line from attacking the ground surfaces or depositing sediment between them.

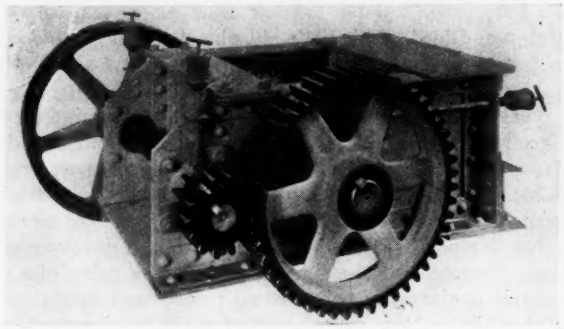
It will be noted from the illustration that the lubricant can be removed from time to time. The grooves which carry the lubricant to the surface of the plug are so arranged that they cover most of the seating each time a quarter turn is made. At the same time, they never cross the openings of the valve, or come in direct contact with the pressure passing through the valve, so that there is no opportunity for the lubricant to drain out or be carried away by the pressure. The means which have been devised to renew this lubricant is at once original and convenient for the user of the valve.

In a case where the installation consists of a number of valves, they are equipped with Alemite fittings in the top of the stem. In order to renew the lubricant it is only necessary to attach the oil gun, which is supplied in connection with this valve, to force the lubricant into this opening until the reservoir is again filled. When the valves are installed in isolated positions the Madison-Kipp oil cup is used. This is an oil cup which has a reservoir which can be filled with oil from any ordinary oil can. This oil can then be forced into the valve by lifting the ball plunger and pushing it down. By the use of either of these devices the lubricant is forced into the valve at a high pressure and the double ball check with which each of these fittings is equipped prevents the lubricant from being forced down through the upper part of the stem.

This cam construction of the valve has been so changed that the plug is at all times held on the seat, but not tightly enough to prevent the valve being operated easily. This cam also locks the valve plug tightly in the seat in the closed position as heretofore, with the exception that the change in design enables the operator to open the valve more easily and removes any possibility of sticking. As the cam is of solid metal construction and is closely adjusted to allow the plug to turn easily while at the same time holding it on the seat at all times, it will not compress or change its form in any way, hence adjustments of this valve are unnecessary even after it has been in service for some length of time.

Single Roll Crusher Has Frame Made of Steel Plates

FABRICATED STEEL frame, steel shear pin safety device and powerful relief spring are features of a single roll coal crusher recently developed by the Pennsylvania Crusher Co., of Philadelphia. These particular points have been incorporated in the



COAL CRUSHER WHICH IS DESIGNED TO REDUCE BREAKAGE DUE TO TRAMP IRON IN COAL

design to afford protection against the heavy tramp iron often encountered in run of mine coal which has proven so destructive to crushing machinery.

The frame of the original single roll crusher naturally followed somewhat the line of double roll practice; the side frames being set on heavy timber foundations, without metal cross members, aside from the shafts. Later development provided heavy cast iron side frames and cross members. The direct drive of

the roll shaft by means of a large flywheel pulley soon gave place to the powerful back geared drive through countershaft and smaller pulley. For heavy duty the frame was made in one massive box section casting, which later was sectionalized, particularly in the larger sizes.

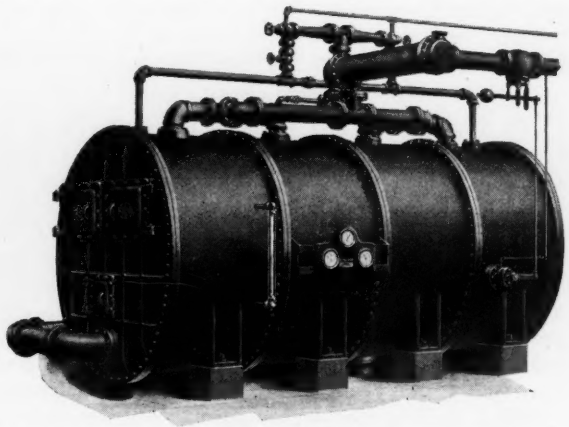
The latest development provides a frame fabricated from slab steel plates into an unbreakable unit. In the 18 by 18-in. and the 18 by 24-in. sizes, in which this design is now available, the steel side plates are 1 in. in thickness and are connected by nine steel cross members all heavily hot riveted into this rigid box frame.

Bronze bushed bearings are shouldered into the heavy side plates so that the bearing bolts are not subjected to shear. The heavy flywheel pulley which drives the roll through heavy cut, back gearing, is provided with a shear pin safety device, mounting a steel bolt in hardened bushings, thereby insuring full protection of the crusher parts against the accidental introduction of tramp iron with coal.

The breaker plate is a massive casting of charcoal iron, deeply chilled on the crushing surface. It is hinged in the frame at the upper end and suspended at the lower end by means of powerful relief springs. The breaker plate tip which takes most of the wear is a reversible and renewable manganese steel casting. The segmental roll is cast from charcoal iron, deeply chilled, or from chrome steel.

Correction for Cochrane De-aerating Heater Description

IN THE description of the de-aerating heater, recently developed by the H. S. B. W.-Cochrane Co., of Philadelphia, appearing in the Nov. 1 issue, the illustration used showed one of their standard heaters. As the new heater differs in many respects from the standard heaters, attention is called to this correction in order to avoid any possible confusion.



DE-AERATING HEATER WHICH MAY BE OPEERATED UNDER A VACUUM

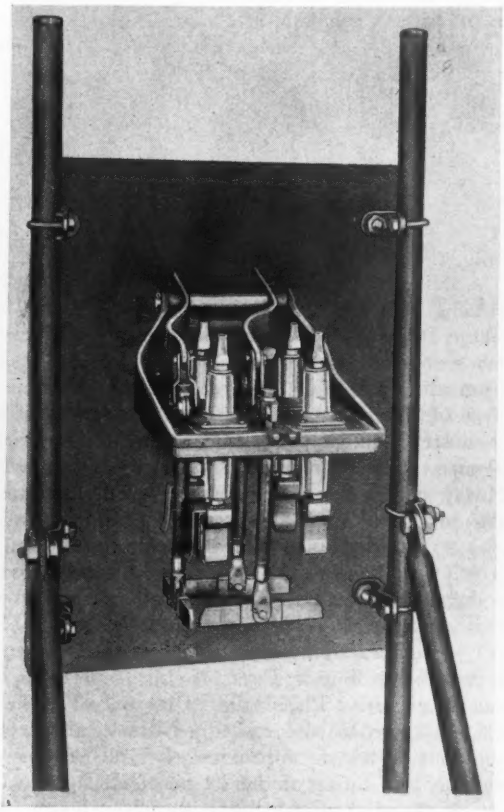
Steam is admitted above the water surface in the standard heater while in the de-aerating heater it is admitted through a perforated manifold at the bottom of the water storage space. The trays of the standard heater are open upon all sides, while in the new type of heater a counter-flow tray stack is used in order to remove the water vapor from the mixture going to the ejector.

As pointed out in the previous article, the de-aerating heater may be operated under a vacuum where it is desired to deliver oxygen free water at temperatures below 212 deg. F. or to have vacuum on the house turbine. It is also necessary to use a vacuum breaker in connection with the overflow.

By referring to the accompanying illustration, it will be seen that the steam enters the heater at the lower left hand side, while the boiler feed pump connection is at the bottom center. At the top are the ejectors, while the raw water enters through the large line at the upper right. The gleaner for removing the heat of ejector steam shows as the larger pipe section at this point. The water to be heated is fed into the heater through the top connections.

Circuit Breaker for High Voltage Lighting Circuits

THE accompaning illustration shows a new type of oil circuit breaker intended for use in connection with constant current transformers for series street lighting circuits. This breaker, which was developed by the General Electric Co., is designed for non-automatic operation, and is built in two varieties, a double-pole, single throw type for either the primary or the secondary side of the current transformer, or a double-



OIL CIRCUIT BREAKER WITH TWO OPERATING HANDLES, SINGLE AND DOUBLE POLES, SINGLE THROW, 4000-V., 60 AMP., FOR USE ON STREET LIGHTING CIRCUITS

pole, single throw breaker with an additional blade for short-circuiting the lighting circuit. The latter type performs the same duty as one short-circuiting and two open-circuiting plug switches. When the breaker is used on the primary side of a transformer it is necessary to use fuses for overload protection.

This type breaker cannot be used on voltages above 45,000-v., 60 amp., its normal rating on primary circuits.

The operating levers are of the fulcrum type without toggle and very simple in construction. The handles of the operating levers are of the bayonet locking type which consists of a spring actuated rod adapted to hold the handle in position by dropping into indentures at either position of the switch on the escutcheon and seal the breaker in position thereby lessening vibration.

El Dorado Plant Progressing Rapidly

AFTER FIVE YEARS of investigation, field and office engineering and study, the Western States Gas & Electric Co. began work during the early part of this year on the first step of its 100,000-hp. hydroelectric development known as the El Dorado plant. The engineering details which had been worked out by the Byllesby Engineering Management Corporation, engineers and fiscal managers of the Western States Gas & Electric Co., were practically complete at that time and work began immediately upon the receipt of the Government permit and upon the consummation of $5,000,000 financing incident to the first step of this development. Certain minor details have been altered, but the program has been followed closely and today the progress which has been made is decidedly satisfactory.

To date, the first step of the preliminary 20,000 kw. installation is approximately 40 per cent complete. During the latter part of next year the first unit will be put in operation, adding 20,000 kw. to the ever-increasing demand for energy on the system of the Stockton Division of Western States Gas & Electric Co., which serves territory in the counties of San Joaquin, Sacramento, El Dorado, Calaveras and Amador.

One of the first steps was the establishment of sanitary construction camps for the accommodation of about 1500 men. The proximity of this project to the State Highway running to Lake Tahoe makes the transportation problems reasonably simple. All material and machinery can be transported at a cost far less than that incurred on other similar projects in the High Sierras. The immediate program as outlined to be completed by December, 1923, is essentially as follows:

(1) Construction of a new power house in the canyon of the South Fork of the American River about 14 mi. above Placerville. One unit of 20,000 kw. or 26,800 hp. is to be installed. Ultimate development to be four units, or approximately 100,000 hp. (2) Enlarging and lining of the 23 mi. of El Dorado Ditch from the forebay above the new power house to the intake on the American River near Kyburz just below the mouth of Silver Fork of American River which carries the water from Silver Lake to Twin Lakes. (3) Construction of penstocks. The water wheels in the power house will operate under a 1900-ft. drop, which will make this one of the high head plants of the country. (4) Construction of a 45-ft. main dam and 26-ft. auxiliary dam at Twin Lakes to create a storage of 16,000 acre feet. (5) Construction of a diverting dam in the South Fork of American River at head of El Dorado Ditch just below Kyburz. (6) Construction of a double transmission line to connect new plants with present transmission system. The potential storage which it is proposed to develop is about 93,000 acre feet in six reservoirs, some of which is already existing.

The center of operation is Headquarters Camp situated on the State Highway at the 14-mi. stone above Placerville. Here the supplies for the power plant and El Dorado Ditch operation are being stored and the field administration for the whole project is maintained. The operations of the whole development with the exception of those at Twin Lakes are being done electrically, the electricity for which is obtained from a temporary transmission line connected to the present 60,000-v. line of the Western States Gas & Electric Co., near Placerville.

Los Angeles Loses in Owens River Water Fight

LOS ANGELES lost its fight to condemn for its own hydroelectric development project the choicest power site on the Owens River recently when the United States Circuit Court of Appeal reversed the victory the municipality won before Federal Judge William C. Van Fleet in July, 1921. The decision which restores the property to the Southern Sierras Power Co. is of importance throughout California, as it held that a municipal corporation has not the right to condemn property which a private corporation is devoting to the public uses of other municipal corporations.

It was the contention of the Southern Sierras Power Co. and its predecessors in ownership, the Mono Power Co., that the needs of six counties and numerous southern California cities and towns were equal to those of Los Angeles. This viewpoint was completely upheld by the Circuit Court.

Southern Power Co. Is Spending $2,000,000 for Transmission Lines

IN ANTICIPATION of the completion next year of its two new hydroelectric plants and its two steam plant additions, which will have a total generating capacity of 200,000 hp., the Southern Power Co. is pushing to as rapid a completion as possible the construction of new high tension transmission lines aggregating more than 200 mi. An idea of the magnitude of this feature of the present construction program of the power company may be given from an unofficial statement that the new transmission lines, not including the large investment that will be required for transformers, switches and incidental equipment, will be approximately $2,000,000.

The longest and one of the most important of the new transmission lines is being built from Lookout generating station, west of Statesville, to Winston-Salem, High Point and Greensboro, a distance of 75 mi. Another important line is being built from Great Falls, S. C., where the new Dearborn hydroelectric station will soon be completed, to Newberry, S. C., a distance of 50 mi. A new line 40 mi. in length is being built from Salisbury. A similar line is under construction between Mountain Island and Gastonia. Another line which

will serve Gastonia is being built from the Mount Holly steam station. A line is also being built from the Mt. Holly steam plant to the Mountain Island hydroelectric plant. A new line is being built from Shelby to Caroleen, and still another from Hickory to Rhodhiss.

The present transmission system of the Southern Power Company embraces approximately 2200 mi. of transmission lines, it being one of the most extensive electric transmission systems in the world today. When the new lines are completed the total mileage of transmission lines will be approximately 2400 mi.

American Shipping Should Take Advantage of Modern Engineering Practice

IN AN ADDRESS on the ship subsidy bill, delivered at the recent American Marine Exposition at the Grand Central Palace, New York City, Frank V. Smith, of the marine engineering department of the General Electric Co., called attention to the futility of government aid unless the enterprises to which it is extended have practiced the maximum economy in operation. This means the employment, not only of the most efficient methods of management, but also of the most advanced types of equipment, such as the Diesel engine, the electric drive, and other improvements as they are perfected. Unless the American companies maintain a high standard in these respects, Mr. Smith said that they would fall behind in the race with foreign competitors, irrespective of government aid. He also pointed out the necessity for better education of marine engineers and others handling the latest types of equipment.

At present American shipping may be said to be marking time in anticipation of action on the subsidy question at the special session of Congress. If the pending legislation passes, a great impetus will undoubtedly be given to privately owned American passenger and freight shipping. In this case, it is expected that several big companies will be formed, for operations on the Atlantic, Gulf and Pacific coasts, respectively. While under present conditions new building would probably be limited to a few ships, including one or two large ones of the Leviathan class, it is likely that many shipyards would be engaged in installing new equipment looking to the highest economy in operation.

If, on the other hand, this legislation fails to pass at this session, it is not considered likely to be revived, and the practical obliteration of privately owned American shipping may be regarded as certain.

John L. Harrington New A. S. M. E. President

AT THE annual meeting of the American Society of Mechanical Engineers to be held in New York on Dec. 4 to 7 John Lyle Harrington will take his seat as the new president of the society.

Mr. Harrington was born at Lawrence, Kan., in December, 1868. After a brief business experience, he entered the University of Kansas in 1891 and was graduated in 1895 with the degrees of A. B., B. S. and C. E. Later he received the degree of M. S. from McGill University, Montreal.

His first six years after graduation were devoted to the acquisition of a broad foundation in bridge, structural and mechanical work with J. A. L. Waddell, consulting engineer, Kansas City, Mo.; with the Elmira Bridge Co., Elmira, N. Y.; with the Pencoyd Iron Works, Philadelphia, Pa.; with the Keystone Bridge Works of the Carnegie Steel Co., Pittsburgh, Pa.; with the Cambria Steel Co., Johnstown, Pa., for whom he designed and supervised the construction and equipment of the bridge and structural shops; as assistant chief engineer of the Bucyrus Co., South Milwaukee, Wis.; as assistant chief engineer of the Northwestern Elevated Railway Co. of Chicago, in charge of the detailing and fabrication of the metal work in the shops; as designer

JOHN LYLE HARRINGTON

for the Berlin Iron Bridge Co., East Berlin, Conn.; and as assistant engineer of bridges and buildings for the Baltimore & Ohio Railroad Co.

From 1901 to 1905 he served as executive engineer (manager) of the C. W. Hunt Co., New York City, and during 1905 and 1906 as chief engineer and manager of the Locomotive and Machine Co. of Montreal, a subsidiary of the American Locomotive Co.

From 1907 to 1914 he was a member of the firm of Waddell and Harrington, consulting engineers, Kansas City, and from 1914 to date he has been the senior partner of the firm of Harrington, Howard and Ash, consulting engineers, Kansas City. During his work as a consulting engineer, which has been devoted largely to the design and supervision of construction of large bridges, he has developed the vertical lift bridge and a variation of it, the movable deck, and has made a specialty of large movable structures of all kinds.

Mr. Harrington became a member of the society in 1902 and is now serving as vice-president and chairman of the Committee on Constitution and By-laws. He is also a member of the American Society of Civil Engineers, the Engineering Institute of Canada, the Institution of Civil Engineers, London, the American Railway

Engineering Association, the American Society for Testing Materials, the honorary societies Sigma Xi and Tau Beta Pi (Past President of the National Council), the Engineers' Club of Kansas City (Past President), the University Club of Kansas City, the Kansas City Club, and the Engineers' Club of Chicago.

Public Utility Load Continues to Grow

DAILY PRODUCTION of electricity by public utility power plants in September again broke all records. This is the third time in four months that records of output have been surpassed. The daily production of electricity in September was 135,200,000 kw.-hr., 3 per cent greater than the August record and nearly 6 per cent greater than the June record.

Owing to the usual seasonal increase in the production of electricity which generally occurs the latter part of each year, the average output for each of the remaining months of the year will probably establish a new record. The total output for the period January to September, inclusive, 1922, was 34,340,000,000 kw.-hr., an increase of about 15 per cent over the similar period in 1921. Probably the most important factor in producing this unprecedented demand for electricity is the increase in the domestic and commercial load for illumination and power purposes.

Consumption of both oil and gas in the production of electric power broke all records in August and September, the consumption of these two fuels in September being especially large in comparison with previous months of this year and of the other years of record, indicating an abnormal use of these fuels which has probably been brought about by the difficulty in obtaining coal.

News Notes

ELECTIONS OF EXECUTIVE committees of the professional divisions were announced recently by the American Society of Mechanical Engineers. L. P. Breckenridge, professor of mechanical engineering, Yale University, is chairman of the fuels division. John H. Lawrence, New York City, is chairman of the power division and Van H. Manning heads the gas power division.

LICENSING ENGINEERS will be the subject of a joint meeting of the New York sections of the A. S. C. E., A. I. M. E., A. S. M. E., and A. I. E. E., to be held at the Engineering Societies Building on Dec. 13.

ALUMNI OF THE Massachusetts Institute of Technology gave a banquet on Nov. 22 to Dr. W. S. Stratton, who recently resigned his position as head of the Bureau of Standards to accept the presidency of "Tech."

PERMISSION HAS been asked of the Coal Commission by the Chamber of Commerce of the United States, that the Chamber be allowed to present the views of organized business and industry should the Commission seriously consider any proposal looking to the nationalization of the coal industry. Julius H. Barnes, president of the National Chamber, in a letter to the Commission pointed out the disastrous consequences of the nationalization of various industries in Russia and other countries of Europe.

CONSIDERATION of a system of designating qualities or kinds of steels by code numbers will be taken up in a conference which has been called by the American Engineering Standards Committee at the request of the U. S. Bureau of Standards. The conference will be held in Room 704, Department of Commerce Building, Nineteenth St. and Pennsylvania Ave., Washington, D. C., at 10 a. m., Dec. 6. This conference is a matter of great importance to all manufacturers of steel and to all users of steel in large quantity. An attempt will be made to determine the desirability of applying a uniform numbering system to forging steels, casting steels, structural steels, including plates, tool steels or other steels not so classified.

TEN EGYPTIAN STUDENTS, graduates of the engineering and polytechnic schools of Egypt, sent to America by the Khedive's government to learn American manufacturing methods arrived recently in Washington and have been placed by the Department of Commerce in automobile and other factories where they will for two years work as actual employes, with the purpose of carrying back to the land of the pyramids the industrial and technical knowledge and skill of the Yankees.

DUKE GELASIA CAETANI, the new ambassador from Italy, is a mining and civil engineer, as well as an electrical expert, who received much of his training at Cornell University and other American schools.

R. L. BEERS, who was recently appointed chief engineer of the Detroit Stoker Co., graduated from Syracuse University in the class of 1912 in mechanical engineering. Leaving the university he spent four years with the United States Bureau of Mines under Mr. Hood, doing research and testing work on various fuels and combustion apparatus. Mr. Beers left the government service to do special combustion work with the United States Radiator Corporation.

Four years ago he was appointed testing engineer of the Underfeed Stoker Company of America and was later promoted to the position of assistant chief engineer. While with this company he was particularly active in the development of new stokers and made a special study of the application of underfeed stokers to industrial furnaces and the burning of refuse material.

In his new position Mr. Beers will be in direct charge of the design and application of the Detroit Stoker Co.'s single retort and multiple retort underfeed stokers.

CHARLES J. TAGLIABUE, president of The C. J. Tagliabue Manufacturing Co., Brooklyn, died on Nov. 2.

W. W. SAYERS, of the Link-Belt Co., has been made chief engineer of the company's Philadelphia Works and Eastern operations.

JOHNS-PRATT CO., of Hartford, Conn., announces the appointment of George Saylor as western sales manager, electrical division, with headquarters at 36-37 South Desplaines St., Chicago.

JENKINS BROS. announces the appointment of William G. Le Compte as sales manager in charge of its New York territory. Mr. Le Compte has been a member of the sales organization of this company for 25 yr.

THE FLORANDIN EQUIPMENT CO., 110 West 40th St., New York City, which is New York representative of the Conveyors Corporation of America, Chicago, is

also representing the Perfection Grate and Supply Co., Springfield, Mass., manufacturers of hand stokers and soot cleaners.

ANNOUNCEMENT IS MADE by the Standard Turbine Corporation, of Wellsville, N. Y., of the appointment of E. E. Maher as district sales manager in Chicago, with offices at 2237 Insurance Exchange Building. The Chicago office will handle business for the greater part of Indiana, Illinois and Iowa.

BECAUSE OF increased demand in its steam specialty line, the Reliance Gauge Column Co., Cleveland, has sold the Cleveland clutch business to the Western Engineering & Manufacturing Co., of Chicago. The latter company has been incorporated as a subsidiary of the Western Valve Bag Co.

CHANGES IN THE PERSONNEL of the district offices of the Westinghouse Electric & Manufacturing Co. have been announced by W. S. Rugg, general sales manager. In the Pittsburgh office, the power division has been changed to the central station division with Barton Stevenson as manager. Mr. Stevenson will also be in charge of the sale of supply apparatus throughout the entire Pittsburgh district. The railway division has been changed to the transportation division, with F. G. Hickling as manager. A merchandising division has also been organized of which F. C. Albrecht has been appointed manager.

TAYLOR UNDERFEED STOKERS are being installed in the Capitol Traction Company's plant at Wisconsin Ave. & K St., Washington. The boiler plant is made up of four 600-hp. B. & W. boilers and the original stoker installation has been in service for 11 yr. Air is supplied to the six-retort system by two Buffalo Forge fans driven by Terry turbines. These fans will supply 52,000 cu. ft. of air per minute, operating against a 6-in. static head. Chief Engineer Palgleish of the Traction Co. states that the peak load on the system runs about 8000 kw. in the summer months and 12,000 kw. during the winter.

ON NOV. 1, the name of the Walter L. Flower Co., of St. Louis, was changed to Stewart-Thill Co. Since Mr. Flower's death in 1917, the business has been run by N. Stewart, who has, on account of the growth of the business, found it necessary to enlarge the organization. Mr. Thill has had a long experience in the power plant field. This organization handles the lines of H. S. B. W.-Cochrane Corp., Strong, Carlisle & Hammond Co., Lea-Courtenay Co., Dean Bros. Steam Pump Works, Weinman Pump Co., and Hills-McCanna Co. in St. Louis territory.

WORK WILL BEGIN shortly on a 75-T. ice plant for the Paducah Ice Co., Paducah, Ky. The York Manufacturing Co. will furnish the equipment.

OWING TO INCREASED business, the Denver Ice and Cold Storage Co., of Denver, Colo., finds it necessary to build more storage room. Two structures will be erected, each 70 ft. high and 65 by 80 ft. ground area. The complete cost for the new buildings will be about $100,000.

DURING THE continuance of draughts in the Blue Ridge and Piedmont watersheds from the Susquehanna to the Savannah, the power company at Harrisonburg, Va., on the Shenandoah, has been forced to shut off its power and lighting service during the hours from midnight to 7:00 a. m.

GROUND HAS been broken in Los Angeles for an electrical manufacturing plant for Brown and Pengilly. The building will have a floor area of about 15,000 sq. ft. This firm manufactures switches, switchboards, panels, steel cabinets, pumping plant panels, overload relays and cutouts. Special apparatus is also designed and built in a laboratory maintained for electrical testing.

THE ILLINOIS ELECTRIC CO. is constructing a new building in Los Angeles, which when completed will represent an expenditure by the firm of approximately $250,000. It is four stories high, and of fireproof construction, and will be ready for occupancy about December 1. The structure will house the warehousing, distributing and servicing facilities as well as the executive offices of the firm.

CONSOLIDATION OF THE general offices of the Pacific Gas & Electric Co. in San Francisco will be effected by the construction of a seventeen story office building.

The construction of the building will be first class in every particular, steel concrete and brick being employed throughout, except for the exterior which will be of terra cotta with a granite base. Marble will be used extensively on the first floor and marble tile in the upstairs corridors.

Provision is made on the sixteenth floor for a general employes' lunch room. Other employes' activities are amply provided for, in the way of a library, rest rooms and conference rooms. The elevator machinery tanks and other necessary mechanical equipment are placed in the attic story, so that the roof will not be disfigured by pent houses and other unsightly structures.

Forced ventilation has been adopted for the lower stories to obviate noise and dust entering through open windows on the street fronts. One of the more novel features of the design is the provision of a parking space for automobiles in the basement, access to which is obtained by way of a ramp descending from a side street.

GROUND HAS BEEN broken at Galion, Ohio, for a $150,000 municipal power plant. The present plant is too small to supply the requirements. Although municipally owned, the plant is reported to have been a financial success for years.

WHEELING, W. VA., is preparing to submit specifications for its new $2,000,000 municipal pumping station and power plant. The survey of the plants is being made by the J. N. Chester Engineering Corporation, states City Manager C. E. Dowler.

APPLICATION has been filed with the Federal Power Commission by the City of Los Angeles, Calif., for a license for a proposed power house to be built on its aqueduct from Owens River to the City of Los Angeles at a point known as Haiwee Narrows, about two miles below the Haiwee reservoir, in Inyo County, Calif. This power house will have a capacity of approximately 6400 hp.

M. C. SEAGRAVE has applied to the Federal Power Commission for a preliminary permit for a combined

power and irrigation project, including a dam and reservoir, on the headwaters of the North Fork of the Cosumnes River, near Placerville, in Eldorado County, California. A canal five miles long will be constructed to a power house with an installed capacity of appoximately 13,000 hp. A portion of the power will be used for pumping for irrigation, and the remainder will be sold to existing public utility companies.

ORDERS FOR TWO 25,000-kv.a. alternating current generators have been received by the International General Electric Co. for installation in the Parahyba station of the Brazilian Hydro-Electric Co. This station is located on the Parahyba River about 100 mi. from Rio and will operate in connection with the existing generating and transmission systems of the Rio de Janeiro Tramway, Light & Power Co. Power will be transmitted at 132,000 v. The ultimate capacity of the station will be approximately 125,000 kv.a.

Books and Catalogs

MEXICAN PETROLEUM, edited by W. J. Archer, 300 pages, 5 by 7½-in., illustrated, flexible binding.

This extremely interesting and attractive book has for its principal purpose the supplying of information in reference to the development of the Pan American Petroleum & Transport Co. It is written in a popular vein and contains a survey of the vast areas of productive oil land in Mexico and California; a short account of refining and refineries; details in reference to the transportation of oil; and a supplementary chapter giving statistics and engineering data of value to engineers who use oil products. The book contains nine chapters, all of which are extremely interesting reading; but the one of most value to power plant engineers is entitled "Advantages of Fuel Oil and Installations for Stationary Plants." In this chapter are cited eight advantages: Economy in labor, labor more efficient, higher boiler efficiency, flexibility, absence of dirt, reduced cost in maintenance and equipment, bunkering, and saving in space. The chapter goes on further to discuss the problems met in changing a plant over from coal burning to oil burning, taking up furnace design and types of burners.

BELT CONVEYORS AND BELT ELEVATORS, by Frederic V. Hetzel, 333 pages, 6 by 9 in., illustrated, cloth binding; price, $5.

Only a few years has the handling of material by machinery assumed the importance of a separate branch of mechanical engineering and we find in this book, which has just come off the press, a comprehensive treatment of the subject of materials handling by means of belts, including a great amount of data, which has not appeared in print before, dealing not only with the underlying principles of design and manufacture of belt conveying equipment, but with the installation and operation of this equipment. An idea of the scope of the book may be had from the list of chapter headings which follows: General description of component parts, development of belt conveyors, belts and belt manufacture, supporting and guiding the belt, driving the belt, tension and take-up devices, loading the belt, discharging the belt, protecting and cleaning the belt, package conveyors, special uses for belt conveyors, life of belts, when to use belt conveyors, general descriptions of belt elevators, centrifugal discharge elevators, elevator buckets, continuous bucket elevators, belts for elevators, fastening boots, inclined elevators, elevator casings. This book is of especial interest to men who are in charge of materials handling machinery, consulting engineers and engineers and draftsmen who design conveying and elevating machinery.

THERMODYNAMICS, BY J. E. EMSWILER, 266 pages, 6 by 9 in., illustrated, first edition, New York; price $3.

In his preface, the author, who is professor of mechanical engineering at the University of Michigan, says of this book that it is an attempt to present the subject matter with especial regard to the student's viewpoint; that it was the aim in the various developments to proceed progressively so that the reader may easily recognize the relation of each new demonstration that he faces to the whole. With this object in view, the two features of the book which characterize it from other works on the subject are the order of presentation of the various subdivisions of the subject, and the presentation at the beginning of a section of the subject of a schematic diagram of an actual heat engine whose principle is to be exemplified. The book is intended for college students well along in their course and familiar with mathematics up to and including calculus, but would also be of value to any engineer who wished to study up on the theory of the steam power plant, vapor refrigeration, compression and expansion of permanent gases, air heat engine, the flow of fluids, the steam turbine or the injector.

DEAERATION OF WATER to prevent corrosion in piping, economizers and boilers is discussed in a booklet published by the H. S. B. W.-Cochrane Corporation, Philadelphia, Pa. The apparatus described is designed to deliver water free of dissolved oxygen, at any temperature from 140 deg. F. up, as required for hot water heating and service systems and for feeding to economizers and boilers. Charts are given showing the amount of iron converted into rust by water containing different amounts of oxygen, vapor pressures, corresponding to water temperatures and solubilities of oxygen and nitrogen in water at various temperatures and pressures. The Winkler test for detecting dissolved oxygen in water is also described.

LINK-BELT calendar for 1923 will be ready for distribution early in December. The calendar measures 15½ by 24 in. and contains 12 separate full sheets. Each has an attractive illustration of Link-Belt machinery and equipment. Underneath each month's large calendar are shown the previous month and the succeeding month. A number of extra copies are available and can be obtained by addressing the Link-Belt Co., 910 South Michigan Ave., Chicago, on the letterhead of your firm.

ELEMENTS of Industrial Heating is the title of a booklet from W. S. Rockwell Co., 50 Church St., New York, which represents an effort to encourage a broader view of the principles governing the heat-treatment of metallurgical, chemical and ceramic products, and the selection and use of equipment, fuel or electricity as a means to that end. The matter is entirely technical and relates to principles and their application in practice. Data is included which should be of interest to those concerned with the use of heat in industrial operations.